Indiana University Health

Indiana University Health Medical Center Campus

CENTRAL UTILITY PLANT

100% Design Document Architectural and MEP Technical Specifications

February 10, 2023

Applied Engineering Services

VPS ARCHITECTURE

Cripe

CE Solutions structural engineers

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INTRODUCTORY INFORMATION

SECTION 017419 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for the following:

1. Salvaging nonhazardous demolition and construction waste.
2. Recycling nonhazardous demolition and construction waste.
3. Disposing of nonhazardous demolition and construction waste.

B. Related Requirements:

1. Section 024119 "Selective Demolition" for disposition of waste resulting from partial demolition of buildings, structures, and site improvements and for disposition of hazardous waste.
2. Section 042200 “Concrete Unit Masonry” for disposal requirements for masonry waste.
3. Section 044300 “Stone Cladding” for disposal requirements for excess stone and stone waste.
4. Section 321400 “Unit Paving” for disposal requirements for excess stone paving and stone paving waste.
5. Division 31 for disposition of waste resulting from excavation and removal of above and below grade improvements.

1.3 DEFINITIONS

A. Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.

B. Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.

C. Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.

D. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.

E. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.

F. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.

1.4 PERFORMANCE REQUIREMENTS

A. General: Achieve end-of-Project rates for salvage/recycling of 50 percent minimum by weight of total non-hazardous solid waste generated by the Work. Practice efficient waste management in the use of materials in the course of the Work. Use all reasonable means to divert construction and demolition waste from landfills and incinerators. Facilitate recycling and salvage of materials including, but not limited to the following to achieve LEED goals.

1. Demolition Waste:

a. Asphalt paving.
b. Concrete.
c. Concrete reinforcing steel.
d. Brick.
e. Concrete masonry units.
f. Wood studs.
g. Wood joists.
h. Plywood and oriented strand board.
i. Wood paneling.
j. Wood trim.
k. Structural and miscellaneous steel.
l. Rough hardware.
m. Roofing.
n. Insulation.
o. Doors and frames.
p. Door hardware.
q. Windows.
r. Glazing.
s. Metal studs.
t. Gypsum board.
u. Acoustical tile and panels.
v. Carpet.
w. Carpet pad.
x. Demountable partitions.
y. Equipment.
z. Cabinets.
aa. Plumbing fixtures.
bb. Piping.
cc. Supports and hangers.

dd. Valves.
ee. Sprinklers.
ff. Mechanical equipment.
gg. Refrigerants.
hh. Electrical conduit.
ii. Copper wiring.
jj. Lighting fixtures.
kk. Lamps.
ll. Ballasts.
mm. Electrical devices.
nn. Switchgear and panelboards.
oo. Transformers.

2. Construction Waste:

a. Masonry and CMU.
b. Lumber.
c. Wood sheet materials.
d. Wood trim.
e. Metals.
f. Roofing.
g. Insulation.
h. Carpet and pad.
i. Gypsum board.
j. Piping.
k. Electrical conduit.
l. Packaging: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following uncontaminated packaging materials:

1) Paper.
2) Cardboard.
3) Boxes.
4) Plastic sheet and film.
5) Polystyrene packaging.
6) Wood crates.
7) Plastic pails.

1.5 ACTION SUBMITTALS

A. Waste Management Plan: Submit plan within 30 days of date established for the Notice to Proceed.

1.6 INFORMATIONAL SUBMITTALS

A. Waste Reduction Reports: Submit report using Form CWM-7 for construction waste and Form CWM-8 for demolition waste. Include the following information:

1. Material category.
2. Generation point of waste.
3. Total quantity of waste in tons (tonnes).
4. Quantity of waste salvaged, both estimated and actual in tons (tonnes).
5. Quantity of waste recycled, both estimated and actual in tons (tonnes).
6. Total quantity of waste recovered (salvaged plus recycled) in tons (tonnes).
7. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.

B. Waste Reduction Calculations: Before request for Substantial Completion, submit calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.

C. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

D. Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals or organizations. Indicate whether organization is tax exempt.

E. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

F. LEED Submittal: LEED letter template for Credit, signed by Contractor, tabulating total waste material, quantities diverted and means by which it is diverted, and statement that requirements for the credit have been met.

G. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

H. Qualification Data: For waste management coordinator and refrigerant recovery technician.

1.7 QUALITY ASSURANCE

A. Waste Management Coordinator Qualifications: Experienced firm, with a record of successful waste management coordination of projects with similar requirements, that employs a LEED-Accredited Professional, certified by the USGBC, as waste management coordinator. Waste management coordinator may also serve as LEED coordinator.

B. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.

C. Regulatory Requirements: Comply with hauling and disposal regulations of authorities having jurisdiction.

D. Waste Management Conference: Conduct conference at Project site. Review methods and procedures related to waste management including, but not limited to, the following:

1. Review and discuss waste management plan including responsibilities of waste management coordinator.
2. Review requirements for documenting quantities of each type of waste and its disposition.
3. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
4. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
5. Review waste management requirements for each trade.

1.8 WASTE MANAGEMENT PLAN

A. General: Develop a waste management plan according to ASTM E 1609 and requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. Distinguish between demolition and construction waste. Indicate quantities by weight or volume but use same units of measure throughout waste management plan. (Note: CWM forms referenced are included at the end of this section).

B. Waste Identification: Indicate anticipated types and quantities of demolition and construction waste generated by the Work. Use Form CWM-1 for construction waste and Form CWM-2 for demolition waste. Include estimated quantities and assumptions for estimates.

C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Use Form CWM-3 for construction waste and Form CWM-4 for demolition waste. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.

1. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work.
2. Salvaged Materials for Sale: For materials that will be sold to individuals and organizations, include list of their names, addresses, and telephone numbers.
3. Salvaged Materials for Donation: For materials that will be donated to individuals and organizations, include list of their names, addresses, and telephone numbers.
4. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
5. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.

6. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location where materials separation will be performed.

D. Cost/Revenue Analysis: Indicate total cost of waste disposal as if there was no waste management plan and net additional cost or net savings resulting from implementing waste management plan. Use Form CWM-5 for construction waste and Form CWM-6 for demolition waste. Include the following:

1. Total quantity of waste.
2. Estimated cost of disposal (cost per unit). Include hauling and tipping fees and cost of collection containers for each type of waste.
3. Total cost of disposal (with no waste management).
4. Revenue from salvaged materials.
5. Revenue from recycled materials.
6. Savings in hauling and tipping fees by donating materials.
7. Savings in hauling and tipping fees that are avoided.
8. Handling and transportation costs. Include cost of collection containers for each type of waste.
9. Net additional cost or net savings from waste management plan.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.

1. Comply with operation, termination, and removal requirements in Section 015000 "Temporary Facilities and Controls."

B. Waste Management Coordinator: Engage a waste management coordinator to be responsible for implementing, monitoring, and reporting status of waste management work plan. Coordinator shall be present at Project site full time for duration of Project.

C. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work.

1. Distribute waste management plan to everyone concerned within three days of submittal return.
2. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.

D. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged, recycled, reused, donated, and sold.
2. Comply with Section 015000 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

3.2 SALVAGING DEMOLITION WASTE

A. Salvaged Items for Reuse in the Work: Salvage items for reuse and handle as follows:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
3. Store items in a secure area until installation.
4. Protect items from damage during transport and storage.
5. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.

B. Salvaged Items for Sale and Donation: Not permitted on Project site.

C. Salvaged Items for Owner's Use: Salvage items for Owner's use and handle as follows:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area designated by Owner.
5. Protect items from damage during transport and storage.

D. Doors and Hardware: Brace open end of door frames. Except for removing door closers, leave door hardware attached to doors.

E. Equipment: Drain tanks, piping, and fixtures. Seal openings with caps or plugs. Protect equipment from exposure to weather.

F. Plumbing Fixtures: Separate by type and size.

G. Lighting Fixtures: Separate lamps by type and protect from breakage.

H. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.

3.3 RECYCLING DEMOLITION AND CONSTRUCTION WASTE, GENERAL

A. General: Recycle paper and beverage containers used by on-site workers.

B. Recycling Incentives: Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall accrue to Contractor.

C. Preparation of Waste: Prepare and maintain recyclable waste materials according to recycling or reuse facility requirements. Maintain materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.

D. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical according to approved construction waste management plan.

1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.

    a. Inspect containers and bins for contamination and remove contaminated materials if found.

2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
4. Store components off the ground and protect from the weather.
5. Remove recyclable waste from Owner's property and transport to recycling receiver or processor.
6. Co-mingled method of recycling waste may be utilized provided it is performed in accordance with LEED requirements.

3.4 RECYCLING DEMOLITION WASTE

A. Concrete: Remove reinforcement and other metals from concrete and sort with other metals. Recycle concrete waste.

B. Masonry: Remove metal reinforcement, anchors, and ties from masonry and sort with other metals. Recycle masonry waste.

C. Wood Materials: Separate lumber, engineered wood products, panel products, and treated wood materials.

D. Metals: Separate metals by type.

E. Gypsum Board: Store in a dry location. Remove edge trim and sort with other metals. Remove fasteners.

F. Acoustical Ceiling Panels and Tile: Stack large, clean pieces on wood pallets and store in a dry location.

G. Metal Suspension System: Separate metal members including trim, and other metals from acoustical panels and tile and sort with other metals.

H. Carpet and Pad: Roll large pieces tightly after removing debris, trash, adhesive, and tack strips.

1. Store clean, dry carpet and pad in a closed container or trailer provided by Carpet Reclamation Agency or carpet recycler.

I. Carpet Tile: Remove debris, trash, and adhesive.

1. Stack tile on pallet and store clean, dry carpet in a closed container or trailer provided by Carpet Reclamation Agency or carpet recycler.

J. Piping: Separate supports, hangers, valves, sprinklers, and other components by type.

K. Conduit: Store by type.

3.5 RECYCLING CONSTRUCTION WASTE

A. Packaging:

1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
2. Polystyrene Packaging: Separate and bag materials.
3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.

B. Wood Materials:

1. Clean Cut-Offs of Lumber: Handle pieces not to be incorporated into work similar to recycled demolition waste.
2. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.

C. Gypsum Board: Store in a dry location.

3.6 DISPOSAL OF WASTE

A. General: Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.

1. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

B. Burning: Do not burn waste materials.

C. Disposal: Remove waste materials from Owner's property and legally dispose of them.

3.7 ATTACHMENTS

A. Form CWM-1 for construction waste identification.

B. Form CWM-2 for demolition waste identification.

C. Form CWM-3 for construction waste reduction work plan.

D. Form CWM-4 for demolition waste reduction work plan.

E. Form CWM-5 cost/revenue analysis of construction waste reduction work plan.

F. Form CWM-6 cost/revenue analysis of demolition waste reduction work plan.

G. Form CWM-7 for construction waste

H. Form CWM-8 for demolition waste.

END OF SECTION 017419

FORM CWM-1: CONSTRUCTION WASTE IDENTIFICATION							
MATERIAL CATEGORY	**GENERATION POINT**	**EST. QUANTITY OF MATERIALS RECEIVED* (A)**	**EST. WASTE - % (B)**	**TOTAL EST. QUANTITY OF WASTE* (C = A x B)**	**EST. VOLUME CY (CM)**	**EST. WEIGHT TONS (TONNES)**	**REMARKS AND ASSUMPTIONS**
Packaging: Cardboard							
Packaging: Boxes							
Packaging: Plastic Sheet or Film							
Packaging: Polystyrene							
Packaging: Pallets or Skids							
Packaging: Crates							
Packaging: Paint Cans							
Packaging: Plastic Pails							
Site-Clearing Waste							
Masonry or CMU							
Lumber: Cut-Offs							
Lumber: Warped Pieces							
Plywood or OSB (scraps)							
Wood Forms							
Wood Waste Chutes							
Wood Trim (cut-offs)							
Metals							
Insulation							
Roofing							
Joint Sealant Tubes							
Gypsum Board (scraps)							
Carpet and Pad (scraps)							
Piping							
Electrical Conduit							
Other:							

* Insert units of measure.

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FORM CWM-2: DEMOLITION WASTE IDENTIFICATION				
MATERIAL DESCRIPTION	**EST. QUANTITY**	**EST. VOLUME CY (CM)**	**EST. WEIGHT TONS (TONNES)**	**REMARKS AND ASSUMPTIONS**
Asphaltic Concrete Paving				
Concrete				
Brick				
CMU				
Lumber				
Plywood and OSB				
Wood Paneling				
Wood Trim				
Miscellaneous Metals				
Structural Steel				
Rough Hardware				
Insulation				
Roofing				
Doors and Frames				
Door Hardware				
Windows				
Glazing				
Acoustical Tile				
Carpet				
Carpet Pad				
Demountable Partitions				
Equipment				
Cabinets				
Plumbing Fixtures				
Piping				
Piping Supports and Hangers				
Valves				
Sprinklers				
Mechanical Equipment				
Electrical Conduit				
Copper Wiring				
Light Fixtures				
Lamps				
Lighting Ballasts				
Electrical Devices				
Switchgear and Panelboards				
Transformers				
Other:				

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FORM CWM-3: CONSTRUCTION WASTE REDUCTION WORK PLAN

MATERIAL CATEGORY	GENERATION POINT	TOTAL EST. QUANTITY OF WASTE TONS (TONNES)	DISPOSAL METHOD AND QUANTITY			HANDLING AND TRANSPORTION PROCEDURES
			EST. AMOUNT SALVAGED TONS (TONNES)	EST. AMOUNT RECYCLED TONS (TONNES)	EST. AMOUNT DISPOSED TO LANDFILL TONS (TONNES)	
Packaging: Cardboard						
Packaging: Boxes						
Packaging: Plastic Sheet or Film						
Packaging: Polystyrene						
Packaging: Pallets or Skids						
Packaging: Crates						
Packaging: Paint Cans						
Packaging: Plastic Pails						
Site-Clearing Waste						
Masonry or CMU						
Lumber: Cut-Offs						
Lumber: Warped Pieces						
Plywood or OSB (scraps)						
Wood Forms						
Wood Waste Chutes						
Wood Trim (cut-offs)						
Metals						
Insulation						
Roofing						
Joint Sealant Tubes						
Gypsum Board (scraps)						
Carpet and Pad (scraps)						
Piping						
Electrical Conduit						
Other:						

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FORM CWM-4: DEMOLITION WASTE REDUCTION WORK PLAN

MATERIAL CATEGORY	GENERATION POINT	TOTAL EST. QUANTITY OF WASTE TONS (TONNES)	DISPOSAL METHOD AND QUANTITY			HANDLING AND TRANSPORTION PROCEDURES
			EST. AMOUNT SALVAGED TONS (TONNES)	EST. AMOUNT RECYCLED TONS (TONNES)	EST. AMOUNT DISPOSED TO LANDFILL TONS (TONNES)	
Asphaltic Concrete Paving						
Concrete						
Brick						
CMU						
Lumber						
Plywood and OSB						
Wood Paneling						
Wood Trim						
Miscellaneous Metals						
Structural Steel						
Rough Hardware						
Insulation						
Roofing						
Doors and Frames						
Door Hardware						
Windows						
Glazing						
Acoustical Tile						
Carpet						
Carpet Pad						
Demountable Partitions						
Equipment						
Cabinets						
Plumbing Fixtures						
Piping						
Supports and Hangers						
Valves						
Sprinklers						
Mechanical Equipment						
Electrical Conduit						
Copper Wiring						
Light Fixtures						
Lamps						
Lighting Ballasts						
Electrical Devices						
Switchgear and Panelboards						

Transformers						
Other:						

FORM CWM-5: COST/REVENUE ANALYSIS OF CONSTRUCTION WASTE REDUCTION WORK PLAN								
MATERIALS	TOTAL QUANTITY OF MATERIALS (VOL. OR WEIGHT) (A)	EST. COST OF DISPOSAL (B)	TOTAL EST. COST OF DISPOSAL (C = A x B)	REVENUE FROM SALVAGED MATERIALS (D)	REVENUE FROM RECYCLED MATERIALS (E)	LANDFILL TIPPING FEES AVOIDED (F)	HANDLING AND TRANSPORTATION COSTS AVOIDED (G)	NET COST SAVINGS OF WORK PLAN (H = D+E+F+G)
Packaging: Cardboard								
Packaging: Boxes								
Packaging: Plastic Sheet or Film								
Packaging: Polystyrene								
Packaging: Pallets or Skids								
Packaging: Crates								
Packaging: Paint Cans								
Packaging: Plastic Pails								
Site-Clearing Waste								
Masonry or CMU								
Lumber: Cut-Offs								
Lumber: Warped Pieces								
Plywood or OSB (scraps)								
Wood Forms								
Wood Waste Chutes								
Wood Trim (cut-offs)								
Metals								
Insulation								
Roofing								
Joint Sealant Tubes								
Gypsum Board (scraps)								
Carpet and Pad (scraps)								
Piping								
Electrical Conduit								
Other:								

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FORM CWM-6: COST/REVENUE ANALYSIS OF DEMOLITION WASTE REDUCTION WORK PLAN								
MATERIALS	TOTAL QUANTITY OF MATERIALS (VOL. OR WEIGHT) (A)	EST. COST OF DISPOSAL (B)	TOTAL EST. COST OF DISPOSAL (C = A x B)	REVENUE FROM SALVAGED MATERIALS (D)	REVENUE FROM RECYCLED MATERIALS (E)	LANDFILL TIPPING FEES AVOIDED (F)	HANDLING AND TRANSPORTATION COSTS AVOIDED (G)	NET COST SAVINGS OF WORK PLAN (H = D+E+F+G)
Asphaltic Concrete Paving								
Concrete								
Brick								
CMU								
Lumber								
Plywood and OSB								
Wood Paneling								
Wood Trim								
Miscellaneous Metals								
Structural Steel								
Rough Hardware								
Insulation								
Roofing								
Doors and Frames								
Door Hardware								
Windows								
Glazing								
Acoustical Tile								
Carpet								
Carpet Pad								
Demountable Partitions								
Equipment								
Cabinets								
Plumbing Fixtures								
Piping								
Supports and Hangers								
Valves								
Sprinklers								
Mech. Equipment								
Electrical Conduit								
Copper Wiring								
Light Fixtures								
Lamps								
Lighting Ballasts								
Electrical Devices								

Switchgear and Panelboards								
Transformers								
Other:								

FORM CWM-7: CONSTRUCTION WASTE REDUCTION PROGRESS REPORT

MATERIAL CATEGORY	GENERATION POINT	TOTAL QUANTITY OF WASTE TONS (TONNES) (A)	QUANTITY OF WASTE SALVAGED		QUANTITY OF WASTE RECYCLED		TOTAL QUANTITY OF WASTE RECOVERED TONS (TONNES) (D = B + C)	TOTAL QUANTITY OF WASTE RECOVERED % (D / A x 100)
			ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (B)	ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (C)		
Packaging: Cardboard								
Packaging: Boxes								
Packaging: Plastic Sheet or Film								
Packaging: Polystyrene								
Packaging: Pallets or Skids								
Packaging: Crates								
Packaging: Paint Cans								
Packaging: Plastic Pails								
Site-Clearing Waste								
Masonry or CMU								
Lumber: Cut-Offs								
Lumber: Warped Pieces								
Plywood or OSB (scraps)								
Wood Forms								
Wood Waste Chutes								
Wood Trim (cut-offs)								
Metals								
Insulation								
Roofing								
Joint Sealant Tubes								
Gypsum Board (scraps)								
Carpet and Pad (scraps)								
Piping								
Electrical Conduit								
Other:								

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FORM CWM-8: DEMOLITION WASTE REDUCTION PROGRESS REPORT

MATERIAL CATEGORY	GENERATION POINT	TOTAL QUANTITY OF WASTE TONS (TONNES) (A)	QUANTITY OF WASTE SALVAGED		QUANTITY OF WASTE RECYCLED		TOTAL QUANTITY OF WASTE RECOVERED TONS (TONNES) (D = B + C)	TOTAL QUANTITY OF WASTE RECOVERED % (D / A x 100)
			ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (B)	ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (C)		
Asphaltic Concrete Paving								
Concrete								
Brick								
CMU								
Lumber								
Plywood and OSB								
Wood Paneling								
Wood Trim								
Miscellaneous Metals								
Structural Steel								
Rough Hardware								
Insulation								
Roofing								
Doors and Frames								
Door Hardware								
Windows								
Glazing								
Acoustical Tile								
Carpet								
Carpet Pad								
Demountable Partitions								
Equipment								
Cabinets								
Plumbing Fixtures								
Piping								
Supports and Hangers								
Valves								
Sprinklers								
Mechanical Equipment								
Electrical Conduit								
Copper Wiring								
Light Fixtures								
Lamps								
Lighting Ballasts								
Electrical Devices								

Switchgear and Panelboards								
Transformers								
Other:								

SECTION 018113.13 - SUSTAINABLE DESIGN REQUIREMENTS - LEED FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements and procedures for compliance with certain USGBC LEED prerequisites and credits needed for Project to obtain LEED-Gold certification based on USGBC's "LEED v4 for New Construction & Major Renovations."

1. Other LEED prerequisites and credits needed to obtain LEED certification depend on product selections and may not be specifically identified as LEED requirements. Compliance with requirements needed to obtain LEED prerequisites and credits may be used as one criterion to evaluate substitution requests and comparable product requests.
2. Additional LEED prerequisites and credits needed to obtain the indicated LEED certification depend on Architect's design and other aspects of Project that are not part of the Work of the Contract.
3. A copy of the LEED Project checklist is attached at the end of this Section for information only.
4. Specific requirements for LEED are included in greater detail in other Sections.

1.3 DEFINITIONS

A. Chain-of-Custody Certificates: Certificates signed by manufacturers certifying that wood used to make products was obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship." Certificates shall include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.

B. Regional Materials: Materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value.

C. Recycled Content: The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

1. "Post-consumer" material is defined as waste material generated by households or by commercial, industrial, and institutional facilities in their role as end users of the product, which can no longer be used for its intended purpose.
2. "Pre-consumer" material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Respond to questions and requests from Architect and the USGBC regarding LEED credits that are the responsibility of the Contractor, that depend on product selection or product qualities, or that depend on Contractor's procedures until the USGBC has made its determination on the project's LEED certification application. Document responses as informational submittals. Contractor shall be responsible for completing online LEED credit forms associated with the construction phase of the Work.

1.5 ACTION SUBMITTALS

A. General: Submit additional LEED submittals required by other Specification Sections.

B. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.

C. LEED Documentation Submittals:

1. Product data and wiring diagrams for sensors and data collection system used to provide continuous metering of building energy-consumption performance over a period of time of not less than one year of postconstruction occupancy.
2. Comply with Section 017419 "Construction Waste Management and Disposal."
3. Receipts for salvaged and refurbished materials used for Project, indicating sources and costs for salvaged and refurbished materials.
4. Product data and certification letter from product manufacturers indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating material cost for each product having recycled content.
5. Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
6. Product data and chain-of-custody certificates for products containing certified wood. Include statement indicating cost for each certified wood product.
7. Construction Indoor Air Quality:

    a. Construction indoor-air-quality management plan.
    b. Product data for temporary filtration media.
    c. Product data for filtration media used during occupancy.

d. Construction Documentation: Six photographs at three different times during the construction period, along with a brief description of the SMACNA approach employed, documenting implementation of the indoor-air-quality management measures, such as protection of ducts and on-site stored or installed absorptive materials.

8. Indoor Air Quality Assessment:

   a. Signed statement describing the building air flush-out procedures including the dates when flush-out was begun and completed and statement that filtration media was replaced after flush-out.
   b. Product data for filtration media used during flush-out and during occupancy.
   c. Report from testing and inspecting agency indicating results of indoor-air-quality testing and documentation showing compliance with indoor-air-quality testing procedures and requirements.

9. Product data for adhesives and sealants used inside the weatherproofing system indicating VOC content of each product used.
10. Product data for paints and coatings used inside the weatherproofing system indicating VOC content of each product used.
11. Product data for products containing composite wood or agrifiber products or wood glues indicating that they do not contain urea-formaldehyde resin.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For LEED coordinator.

B. Project Materials Cost Data: Provide statement indicating total cost for materials used for Project. Costs exclude labor, overhead, and profit. Include breakout of costs for the following categories of items:

1. Furniture.
2. Plumbing.
3. Mechanical.
4. Electrical.
5. Specialty items such as elevators and equipment.
6. Wood-based construction materials.

C. LEED Action Plans: Provide preliminary submittals within 30 days of date established for the Notice of Award indicating how the following requirements will be met:

1. Waste management plan complying with Section 017419 "Construction Waste Management and Disposal."
2. List of proposed salvaged, refurbished, and reused materials. Identify each material that will be salvaged, refurbished, or reused, including its source, cost, and replacement cost if the item was to be purchased new.

3. List of proposed materials with recycled content. Indicate cost, post-consumer recycled content, and pre-consumer recycled content for each product having recycled content.
4. List of proposed regional materials. Identify each regional material, including its source, cost, and the fraction by weight that is considered regional.
5. List of proposed certified wood products. Indicate each product containing certified wood, including its source and cost of certified wood products.
6. Construction indoor-air-quality management plan.

D. LEED Progress Reports: Concurrent with each Application for Payment, submit reports comparing actual construction and purchasing activities with LEED action plans for the following:

1. Waste reduction progress reports complying with Section 017419 "Construction Waste Management and Disposal."
2. Salvaged, refurbished, and reused materials.
3. Recycled content.
4. Regional materials.
5. Certified wood products.

1.7 QUALITY ASSURANCE

A. LEED Coordinator: Engage an experienced LEED-Accredited Professional to coordinate LEED requirements. LEED coordinator may also serve as waste management coordinator.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Provide products and procedures necessary to obtain LEED credits required in this Section. Although other Sections may specify some requirements that contribute to LEED credits, the Contractor shall determine additional materials and procedures necessary to obtain LEED credits indicated.

2.2 RECYCLED CONTENT OF MATERIALS

A. Building materials shall have recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content for Project constitutes a minimum of 20 percent of cost of materials used for Project.

1. Cost of post-consumer recycled content plus one-half of pre-consumer recycled content of an item shall be determined by dividing weight of post-consumer recycled content plus one-half of pre-consumer recycled content in the item by total weight of the item and multiplying by cost of the item.

2. Do not include plumbing, mechanical and electrical components, and specialty items such as elevators and equipment in the calculation.

2.3 REGIONAL MATERIALS

A. Not less than 20 percent of building materials (by cost) shall be regional materials.

2.4 CERTIFIED WOOD

A. Not less than 50 percent (by cost) of wood-based materials shall be produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship" or Forests Meeting SFI, ATFS, or CSA certificate criteria.

1. Wood-based materials include, but are not limited to, the following materials when made from wood, engineered wood products, or wood-based panel products:

a. Rough carpentry.
b. Miscellaneous carpentry.
c. Heavy timber construction.
d. Wood decking.
e. Metal-plate-connected wood trusses.
f. Structural glued-laminated timber.
g. Finish carpentry.
h. Architectural woodwork.
i. Wood paneling.
j. Wood veneer wall covering.
k. Wood flooring.
l. Wood lockers.
m. Wood cabinets.

2.5 LOW-EMITTING MATERIALS

A. For field applications that are inside the weatherproofing system, adhesives and sealants shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24) CDPH Standard v1.2-2017:

1. Wood Glues: 30 g/L.
2. Metal-to-Metal Adhesives: 30 g/L.
3. Adhesives for Porous Materials (Except Wood): 50 g/L.
4. Subfloor Adhesives: 50 g/L.
5. Plastic Foam Adhesives: 50 g/L.
6. Carpet Adhesives: 50 g/L.
7. Carpet Pad Adhesives: 50 g/L.
8. VCT and Asphalt Tile Adhesives: 50 g/L.
9. Cove Base Adhesives: 50 g/L.

10. Gypsum Board and Panel Adhesives: 50 g/L.
11. Rubber Floor Adhesives: 60 g/L.
12. Ceramic Tile Adhesives: 65 g/L.
13. Multipurpose Construction Adhesives: 70 g/L.
14. Fiberglass Adhesives: 80 g/L.
15. Contact Adhesive: 80 g/L.
16. Structural Glazing Adhesives: 100 g/L.
17. Wood Flooring Adhesive: 100 g/L.
18. Structural Wood Member Adhesive: 140 g/L.
19. Single-Ply Roof Membrane Adhesive: 250 g/L.
20. Special-Purpose Contact Adhesive (contact adhesive that is used to bond melamine-covered board, metal, unsupported vinyl, rubber, or wood veneer 1/16 inch or less in thickness to any surface): 250 g/L.
21. Top and Trim Adhesive: 250 g/L.
22. Plastic Cement Welding Compounds: 250 g/L.
23. ABS Welding Compounds: 325 g/L.
24. CPVC Welding Compounds: 490 g/L.
25. PVC Welding Compounds: 510 g/L.
26. Adhesive Primer for Plastic: 550 g/L.
27. Sheet-Applied Rubber Lining Adhesive: 850 g/L.
28. Aerosol Adhesive, General-Purpose Mist Spray: 65 percent by weight.
29. Aerosol Adhesive, General-Purpose Web Spray: 55 percent by weight.
30. Special-Purpose Aerosol Adhesive (All Types): 70 percent by weight.
31. Other Adhesives: 250 g/L.
32. Architectural Sealants: 250 g/L.
33. Nonmembrane Roof Sealants: 300 g/L.
34. Single-Ply Roof Membrane Sealants: 450 g/L.
35. Other Sealants: 420 g/L.
36. Sealant Primers for Nonporous Substrates: 250 g/L.
37. Sealant Primers for Porous Substrates: 775 g/L.
38. Modified Bituminous Sealant Primers: 500 g/L.
39. Other Sealant Primers: 750 g/L.

B. For field applications that are inside the weatherproofing system, paints and coatings shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Flat Paints and Coatings: VOC not more than 50 g/L.
2. Nonflat Paints and Coatings: VOC not more than 150 g/L.
3. Dry-Fog Coatings: VOC not more than 400 g/L.
4. Primers, Sealers, and Undercoaters: VOC not more than 200 g/L.
5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: VOC not more than 250 g/L.
6. Zinc-Rich Industrial Maintenance Primers: VOC not more than 340 g/L.
7. Pretreatment Wash Primers: VOC not more than 420 g/L.
8. Clear Wood Finishes, Varnishes: VOC not more than 350 g/L.
9. Clear Wood Finishes, Lacquers: VOC not more than 550 g/L.
10. Floor Coatings: VOC not more than 100 g/L.
11. Shellacs, Clear: VOC not more than 730 g/L.

12. Shellacs, Pigmented: VOC not more than 550 g/L.
13. Stains: VOC not more than 250 g/L.

C. Composite wood, agrifiber products, and adhesives shall not contain urea-formaldehyde resin.

PART 3 - EXECUTION

3.1 REFRIGERANT REMOVAL

A. Remove CFC-based refrigerants from existing HVAC&R equipment indicated to remain and replace with refrigerants that are not CFC based. Replace or adjust existing equipment to accommodate new refrigerant as described in HVAC Sections.

3.2 MEASUREMENT AND VERIFICATION

A. Implement measurement and verification plan consistent with Option B: Energy Conservation Measure Isolation or Option D: Calibrated Simulation, Savings Estimation Method 2 in the EVO's "International Performance Measurement and Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction."

B. If not already in place, install metering equipment to measure energy usage. Monitor, record, and trend log measurements.

C. Evaluate energy performance and efficiency by comparing actual to predicted performance.

D. Measurement and verification period shall cover at least one year of postconstruction occupancy.

3.3 CONSTRUCTION WASTE MANAGEMENT

A. Comply with Section 017419 "Construction Waste Management and Disposal."

3.4 CONSTRUCTION INDOOR-AIR-QUALITY MANAGEMENT

A. The use of tobacco products inside the building and within 25 ft. of the building entrance during construction is prohibited.

B. Comply with SMACNA's "SMACNA IAQ Guidelines for Occupied Buildings under Construction" 2007 edition, Chapter 3, and ASHRAE 52.2-2007.

1. If Owner authorizes use of permanent heating, cooling, and ventilating systems during construction period as specified in Section 015000 "Temporary Facilities

and Controls," install filter media having a MERV 8 according to ASHRAE 52.2 at each return-air inlet for the air-handling system used during construction.

2. Replace all air filters immediately prior to occupancy.

C. Indoor Air Quality Assessment

1. Air-Quality Testing:

a. Conduct baseline indoor-air-quality testing, after construction ends and prior to occupancy, using testing protocols consistent with the CDPH Standards Method v1.1, Table 4-1. The Maximum Concentration limits for these target compounds are the full CPEL adopted by Cal/EPA OEHHA (June 2014) and as additionally detailed in the USGBC's "Green Building Design and Construction Reference Guide".

b. Demonstrate that the contaminant maximum concentrations listed below are not exceeded:

1) Formaldehyde: 27 ppb.
2) Particulates (PM10): 50 micrograms/cu. m.
3) Total Volatile Organic Compounds (TVOC): 500 micrograms/cu. m.
4) 4-Phenylcyclohexene (4-PH): 6.5 micrograms/cu. m.
5) Carbon Monoxide: 9 ppm and no greater than 2 ppm above outdoor levels.

c. Air-sample testing shall be conducted as follows:

1) All measurements shall be conducted prior to occupancy but during normal occupied hours, and with building ventilation system starting at the normal daily start time and operated at the minimum outside air flow rate for the occupied mode throughout the duration of the air testing.
2) Building shall have all interior finishes installed including, but not limited to, millwork, doors, paint, carpet, and acoustic tiles. Nonfixed furnishings such as workstations and partitions are encouraged, but not required, to be in place for the testing.
3) Number of sampling locations varies depending on the size of building and number of ventilation systems. For each portion of building served by a separate ventilation system, the number of sampling points shall not be less than one per 25,000 sq. ft. (2300 sq. m) or for each contiguous floor area, whichever is larger, and shall include areas with the least ventilation and greatest concentration of VOCs and other contaminants
4) Air samples shall be collected between 3 and 6 feet (0.9 and 1.8 m) above the floor to represent the breathing zone of occupants, and the collection period must occur over a minimum four-hour period.

END OF SECTION 018113.13

LEED v4 BD+C: New Construction
Project Checklist

Project Name: IUHMCC Central Utility Plant (CUP)
Date: 1/27/2023

YES - Required/Compliant	YES - Pursuing	MAYBE - with Assessment	MAYBE - with Cost	NO	Campus Credit (Y?/N)*	Total Credits Available	LEED Submission Phase	Notations: P = Prerequisite; D = Design Phase Submission; C = Construction Phase Submission. Campus Credit: * Pending credit achieved via Campus Master Site (verify)	Std-189.3 Aligned Section	Std-189.3 via LEED?

PI Category:						0		Project Documents				Credit Lead (bold) / Support / (Resource)	Comments
						0	D	PD	Project Information	-		**Leslie North Hall,** Heather	Project Boundary, Building Info (dwgs, narrative, data), Occupancy, ETC

IP Category:						1		Integrative Process				Responsibility	Comments
	1					1	D	IPc1	Integrative Process			**Leslie North Hall,** Heather	Utilize OPR/BOD as starting basis; Add subsequent IP from project team--Heather to review 2nd draft
0	1	0	0	0									

LT Category:						16		Location and Transportation				Responsibility	Comments
	1					1	D	LTc2	Sensitive Land Protection	5.3.1		**Leslie/** Heather	Opt 1: Previously developed land - **Looking to Pursue as Campus, but eitherway, this should be earned by the project**
	2				Y	2	D	LTc3	High Priority Site	5.3.1		**Chris Reinhart**/(August Mack)	Opt 3: Brownfield Path (coord w/August-Mack via Campus - MAYBE status)
	3			2		5	D	LTc4	Surrounding Density and Diverse Uses	5.3.1.1		**Leslie** Campus Heather	**v4.1 Option 3: Use Walk Score (Showing about 62 points) for 2 of 5 Points**
	3					5	D	LTc5	Access to Quality Transit	5.3.1.1 5.3.7.1		**Leslie** Campus Heather	Add additional walking path graphic.
	1				Y	1	D	LTc6	Bicycle Facilities (v4.1)	5.3.7.2		**Madeline Smith** / Chris Reinhart	Coord. bike storage + Shower/Change areas. Requirement could be easy due to low occupancy?
				1	Y	1	D	LTc7	Reduced Parking Footprint			Not Pursuing	Not recommended
	1				Y	1	D	LTc8	Green Vehicles (Electric Vehicles, v4.1, April 2019 addenda)	5.3.7.3		**Madeline Smith** / Harmon-Walsh /VS-Context	v4.1 (April 2019) Opt. 2: 6% EV Ready. Regs need to be met in all campus parking areas for campus credit
0	11	0	0	1									

SS Category:						7		Sustainable Sites				Responsibility	Comments
P						0	C	SSp1	Construction Activity Pollution Prevention	10.3.1.3		**Leslie & CM** / Chris Wiseman	Civil to complete ESC plan and SWPPP--likely completed in March
	1				Y	1	D	SSc1	Site Assessment	5.3.2		**VS-Context** / Chris Reinhart	Guidon to set draft of template, then distribute to teams for comments.
		1			Y	1	D	SSc2	Site Development - Protect or Restore Habitat	5.3.1, 6.3.1.1		**VS-Context** / (Chris Reinhart)	Restore 30% of master site sf, coordinate with Open Space credit requirements
	1				Y	1	D	SSc3	Open Space	5.3.1		**VS-Context** / (Chris Reinhart)	Review calc. details with VS-Context 25% veg. of the 30% (regardless of total %).
		2			Y	2	D	SSc4	Rainwater Management	5.3.4.2 5.3.4.3		**VS-Context** /	v4.1 sub: Retain runoff from 80th percentile (1pt) or 85th (2pts) of rainfall events.
	1				Y	1	D	SSc5	Heat Island Reduction	5.3.5		**VS-Context** / (Chris Reinhart)	Opt. 1: Roof and nonroof-3 yr aged SRI of 64+ for roof, SR of 0.28+ for paving; vegetated surfaces. Opt 2: Parking under Cover-min 75% of spaces under cover. EP avail. For both Options and 100% parking under cover.
	1				Y	1	D	SSc6	Light Pollution Reduction	5.3.6		**VS-Context** / (Chris Reinhart)	No BUG ratings for IUSM outdoor fixtures. Need to pursue Opt. 2? Discuss with VS-Context. **There will need to be coordination between CUP and SITE team for any Exterior Building Lights**
1	4	3	0	0									

****NOTE: SITES Gold certification earns all SS credits. Lower certification level would likely earn several SS credits, but not automatically all.**

WE Category:						11		Water Efficiency				Responsibility	Comments
P					Y	0	D	WEp1	Outdoor Water Use Reduction	6.3.1 6.4.1		**VS-Context**	No irrigation or min. 30% reduction from baseline
P						0	D	WEp2	Indoor Water Use Reduction	6.3.2		**Justin Merriman**/ Mike/ Leslie	Reduce 20% baseline-Use WaterSense fixtures.
P						0	D	WEp3	Building-Level Water Metering	6.3.3		**Justin Merriman**/ Mike/ Leslie	Meter total potable water use for building. IUH will provide sharing commitment letter.
	1			1	Y	2	D	WEc1	Outdoor Water Use Reduction	6.3.1 6.4.1		**VS-Context**	IUSM 100%CD docs complete. Coordination with VS-Context.
	5			1		6	D	WEc2	Indoor Water Use Reduction	6.3.2		**Justin Merriman**/ Mike/ Leslie	Target 35% reduction for 3pts (for 1-pt RP); Currently showing 49% reduction with "waterless" urinal.
	2				Y	2	D	WEc3	Cooling Tower Water Use	6.3.2.3 6.4.2.1		**John Yoder** / IUH	'Once water analysis report is received the design team will analyze if V4 or V4.1 should be used to achieve this credit.
	1					1	D	WEc4	Water Metering	6.3.3		**Justin Merriman**/ Mike/ Leslie	Process water use will be metered as well domestic hot water. Design team will coordinate with IUH O&M to provide additional meters if necessary.
3	9	2	1	1									

EA Category:						33		Energy and Atmosphere				Responsibility	Comments
P						0	C	EAp1	Fundamental Commissioning and Verification	10.3.1.2		**Justin Merriman**/ (Laura H/IUH)/ Leslie	Engage CxA NLT end of DD; follow ASHRAE guidelines
P						0	D	EAp2	Minimum Energy Performance	7.3		**Justin Merriman** / Leslie	ASHRAE 90.1-2010, Min 5% redux v. baseline. (BOD/189.3 ref std is 90.1-2019)
P						0	D	EAp3	Building-Level Energy Metering	7.3.3		**Justin Merriman** / Leslie	Meter total building energy consumption and commit to share w/USGBC (5-years min)
P					Y	0	D	EAp4	Fundamental Refrigerant Management	9.3.3		**Chris Reinhart**	No CFCs

LEED v4 BD+C: New Construction
Project Checklist

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	6					6	C	EAc1	Enhanced Commissioning			**Justin Merriman** / (SSR/K-H/IUH) / Leslie	Determine scope from Enhanced (3pts), Monitoring (+1pt), & Envelope (+2pts)
	9	4	5	2		18	D	EAc2	Optimize Energy Performance	7.3		**Justin Merriman** / Leslie	Target 22% above baseline? EM excludes process equipment for DES function
			1			1	D	EAc3	Advanced Energy Metering	7.3.3		**Justin Merriman** / Leslie	Need analysis of metering opportunities and usefulness to IUH
				2		2	C	EAc4	Demand Response	NR-189.3		Guidon/IUH	Not desired. Would require coordination w/AES (utility)
			3			3	D	EAc5	Renewable Energy Production	7.3.2 7.4.1		**Justin Merriman** / Leslie	For a District (CUP) Energy Model, any included site-based RE can be apportioned to buildings; Std-189 requires building w/solar-ready capacity per formula/roof* area.
	1					1	D	EAc6	Enhanced Refrigerant Management	11.3.1.1		**Justin Merriman** / Leslie	Follow District (CUP) Energy System variation. Calculations done via opt 2 show compliance.
			2			2	C	EAc7	Green Power and Carbon Offsets	10.3.2		Guidon / IUH	Purchase energy-use and/or carbon offsets (50%=1pt, 100%=2pts). of energy use.
4	16	6	12	4									

MR Category:						13			Materials and Resources			Responsibility	Comments
P					Y	0	D	MRp1	Storage and Collection of Recyclables	9.3.4		**Guidon coordinate w/IUH**	Still investigating if Campus path is appropriate or if project-by-project
P						0	C	MRp2	Construction and Demo Waste Management Planning	10.3.1		**Mike Davis** /CM/Leslie	Establish CWM Plan and Specs. Evaluate impact of any modular construction?
		1	1	3		5	C	MRc1	Building Life-Cycle Impact Reduction	9.5.1		**Mike Davis** / Consultant?	v4.1 sub: create LCA base model =1pt: +1pt for 5% design case redux, or +2 pts for 10%.
	1	1				2	C	MRc2	BPDO - Environmental Product Declarations	9.4.1		**Mike Davis** / CM/Leslie	v4.1 sub: Opt-1: 20 EPDs=1pt; Opt-2 (multi-attribute optimize, track cost)=1pt. Pursue both?
		2				2	C	MRc3	BPDO - Sourcing of Raw Materials	9.4.1		**Mike Davis** / CM/Leslie	v4.1 sub: Opt-2: Extraction Practices - 20% by cost =1pt, 40% by cost =2pts
		1	1			2	C	MRc4	BPDO - Material Ingredients	9.4.1		**Mike Davis** / CM/Leslie	v4.1 sub: Opt-1: 20 HPDs=1pt; Opt-2,3 (mat'l / supply-chain optimize, track cost)=1pt. Both?
	2					2	C	MRc5	Construction and Demolition Waste Management	9.3.1 (189.3) 10.3.1.8		CM/Leslie	v4.1 sub; pursuit of opt-1 (50%+) **and** opt-2 (<7.5#/sf) with prefab/modular waste reduction
2	3	5	2	3									

IEQ Category:						16			Indoor Environmental Quality			Responsibility	Comments
P						0	D	EQp1	Minimum Indoor Air Quality Performance	8.3.1		**Justin Merriman** / Leslie	CUP scope appropriate to meet ASHRAE 62 requirements (non-healthcare)
P					Y	0	D	EQp2	Environmental Tobacco Smoke Control	8.3.1.4		**Chris Reinhart** / IUH / IUSM	Coordinate w signage package, campus, and IUSM
	2					2	D	EQc1	Enhanced Indoor Air Quality Strategies	8.3.1		**Justin Merriman/ Mike** / Leslie	Opt-1 (IAQ Strategies) =1pt; Opt-2 (Add'l IAQ Strategies--Increased Ventilation) =1pt
	2	1				3	D	EQc2	Low-Emitting Materials	8.4.2		**Mike Davis** / CM/Leslie	v4.1 sub; pursue 3 to 4 category compliance (5 for Exemplary Performance?)
	1					1	C	EQc3	Construction Indoor Air Quality Management Plan	10.3.1.4		**Mike Davis** / CM/Leslie	Develop and implement IAQ mgmt plan for construction/preoccupancy
	2					2	C	EQc4	Indoor Air Quality Assessment	8.3.1		**Mike Davis**/ CM/Leslie	Pursue via Opt-2 =2pts (Air testing); Opt-1 =1pt (Flush out) not be feasible for CUP?
	1					1	D	EQc5	Thermal Comfort	8.3.2		**Justin Merriman** / Mike/ Leslie	Ashrase 55 calculations will be performed to show compliance with occupied space. Each space will have individual controls.
	2					2	D	EQc6	Interior Lighting	8.3.5		**Mike Davis** /Applied/Leslie	v4.1 sub: meet 1 strategy =1pt; 3 =2pts (strategies: Glare/CRI/Indiv Control/Surf Reflectivity)
		2		1		3	D	EQc7	Daylight	8.4.1		**Mike Davis** /Applied/Leslie	May be achievable for limited program? (simulation better option 2)
		1				1	D	EQc8	Quality Views			**Mike Davis** /Applied/Leslie	May be achievable for limited program?
				1		1	D	EQc9	Acoustic Performance	8.3.3		**Justin Merriman** / Leslie	Unlikely due to type of facility? Verify applicability
2	10	4	0	2									

ID Category:						6			Innovation in Design			Responsibility	Comments
	1				Y	1	D	INpc-1	Pilot: SSpc158: Onsite Carbon Sequestration Through Plantings			VS Context / ?	LEED Pilot credit with full substitution as SITES innovation credit.
	1				Y	1	D		SITES, O+M P8.1: Plan for Sustatinable Site Maintenance			VS Context / ?	Targeted on SITES 4/29/2022 scorecard.
	1				Y	1	D		SITES, S+V C4.8: Optimize Biomass			VS Context / ?	Targeted on SITES 4/29/2022 scorecard.
		1			Y	1	D		SITES, Materials C5.10: Support Sustainability in Plant Production			VS Context / ?	Targeted on SITES 4/29/2022 scorecard.
	1				Y	1	D		Innovation: Community Outreach via SITES: Pre-Design C2.4: Engage Users and Stakeholders			VS Context / ?	Targeted on SITES 4/29/2022 scorecard.
	1					1	C	INc6	LEED Accredited Professional			Guidon	Submit certificate w/Construction Phase Review (final docs)
0	5	1	0	0									

RP Category:						4			Regional Priority (46202)(LEEDv4-HC)(Master Site)			Responsibility	Comments
	1				Y	1	D	LTc3	Regional Priority: High Priority Site			Guidon	via Master Site / Min Threshold =1pt
	1				Y	1	D	LTc6	Regional Priority: Bicycle Facilities			Madeline Smith / Chris Reinhart	via Master Site / v4.1 sub / Min Threshold =1pt
				1	N	1	D	SSc4	Regional Priority: Rainwater Management			VS-Context /	via Master Site / v4.1 sub / Min Threshold =1pt / (Currently not achievable)
		1				1	D	EAc2	Regional Priority: Optimize Energy Performance			Justin Merriman / Leslie	Min Threshold: 9pts (22%> baseline)
		1				1	C	MRc1	Regional Priority: Building Life Cycle Impact Reduction			Mike Davis / Consultant?	Min Threshold: 1pt / (via Option-4, LCA path)
	1					1	D	EQc7	Regional Priority: Enhanced IAQ			Mike Davis	Min Threshold: 1pt
0	3	2	1	3									

	62	23	16	14		110		TOTALS

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

SECTION 042000 - UNIT MASONRY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Concrete masonry units.
2. Clay face brick.
3. Concrete building brick.
4. Mortar and grout.
5. Steel reinforcing bars.
6. Masonry-joint reinforcement.
7. Ties and anchors.
8. Embedded flashing.
9. Miscellaneous masonry accessories.

B. Products Installed but not Furnished under This Section:

1. Cast-stone trim in unit masonry.
2. Steel lintels in unit masonry.
3. Steel shelf angles for supporting unit masonry.
4. Cavity wall insulation.

C. Related Requirements:

1. Section 051200 "Structural Steel Framing" for installing anchor sections of adjustable masonry anchors for connecting to structural steel frame.
2. Section 072100 "Thermal Insulation" for cavity wall insulation.
3. Section 076200 "Sheet Metal Flashing and Trim" for exposed sheet metal flashing and for furnishing manufactured reglets installed in masonry joints.
4. Section 321400 "Unit Paving" for exterior unit masonry paving.

1.3 DEFINITIONS

A. CMU(s): Concrete masonry unit(s).

B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. For Materials and Resources credit-Building Product Disclosure and Optimization Sourcing of Raw Materials Choose Option 1 or 2.

C. Shop Drawings: For the following:

1. Reinforcing Steel: Detail bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315.
2. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.

D. Samples for Verification: For each type and color of the following:

1. Brick, in the form of straps of five or more bricks.
2. Special brick shapes.
3. Weep holes and cavity vents.
4. Accessories embedded in masonry.

1.6 INFORMATIONAL SUBMITTALS

A. List of Materials Used in Constructing Mockups: List generic product names together with manufacturers, manufacturers' product names, model numbers, lot numbers, batch numbers, source of supply, and other information as required to identify materials used. Include mix proportions for mortar and grout and source of aggregates.

1. Submittal is for information only. Receipt of list does not constitute approval of deviations from the Contract Documents unless such deviations are specifically brought to the attention of Architect and approved in writing.

B. Material Certificates: For each type and size of the following:

1. Masonry units.

a. Include data on material properties.

b. For brick, include size-variation data verifying that actual range of sizes falls within specified tolerances.
c. For exposed brick, include test report for efflorescence according to ASTM C 67.

2. Integral water repellant used in CMUs.
3. Cementitious materials. Include name of manufacturer, brand name, and type.
4. Mortar admixtures.
5. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
6. Grout mixes. Include description of type and proportions of ingredients.
7. Reinforcing bars.
8. Joint reinforcement.
9. Anchors, ties, and metal accessories.

C. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.

1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C 109/C 109M for compressive strength, ASTM C 1506 for water retention, and ASTM C 91/C 91M for air content.
2. Include test reports, according to ASTM C 1019, for grout mixes required to comply with compressive strength requirement.

D. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

1.7 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Build mockups for typical exterior wall in sizes approximately 48 inches (1200 mm) long by 48 inches (1200 mm) high by full thickness, including face and backup wythes and accessories.

a. Include a sealant-filled joint at least 16 inches (400 mm) long in each mockup.
b. Include through-wall flashing installed for a 24-inch (600-mm) length in corner of exterior wall mockup approximately 16 inches (400 mm) down from top of mockup, with a 12-inch (300-mm) length of flashing left exposed to view (omit masonry above half of flashing).
c. Include veneer anchors, flashing, cavity drainage material, and weep holes in exterior masonry-veneer wall mockup.

2. Where masonry is to match thinbrick precast concrete, erect mockups adjacent and parallel to precast concrete.
3. Clean one-half of exposed faces of mockups with masonry cleaner as indicated.

4. Protect accepted mockups from the elements with weather-resistant membrane.
5. Approval of mockups is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.

    a. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Deliver preblended, dry mortar mix in moisture-resistant containers. Store preblended, dry mortar mix in delivery containers on elevated platforms in a dry location or in covered weatherproof dispensing silos.

E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.9 FIELD CONDITIONS

A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.

1. Extend cover a minimum of 24 inches (600 mm) down both sides of walls, and hold cover securely in place.
2. Where one wythe of multiwythe masonry walls is completed in advance of other wythes, secure cover a minimum of 24 inches (600 mm) down face next to unconstructed wythe, and hold cover in place.

B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least three days after building masonry walls or columns.

C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.

1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
2. Protect sills, ledges, and projections from mortar droppings.
3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.

D. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F (4 deg C) and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.

E. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.

B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.

2.2 UNIT MASONRY, GENERAL

A. Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6, except as modified by requirements in the Contract Documents.

B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work.

C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated.

1. Where fire-resistance-rated construction is indicated, units shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction.

2.3 CONCRETE MASONRY UNITS

A. Regional Materials: CMUs shall be manufactured within 100 miles of Project site from aggregates and cement that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

B. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.

1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
2. Provide bullnose units for outside corners of interior partitions unless otherwise indicated.

C. Insulated CMUs: Where indicated, units shall contain rigid, specially shaped, cellular thermal insulation units complying with ASTM C 578, Type I, designed for installing in cores of masonry units.

D. CMUs: ASTM C 90.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2150 psi (14.8 MPa).
2. Density Classification: Normal weight unless otherwise indicated.
3. Size (Width): Manufactured to dimensions 3/8 inch (10 mm) less than nominal dimensions.

E. Concrete Building Brick: ASTM C 55.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2800 psi (19.3 MPa).
2. Density Classification: Normal weight.
3. Size (Actual Dimensions): 3-5/8 inches (92 mm) wide by 2-1/4 inches (57 mm) high by 7-5/8 inches (194 mm) long.

2.4 MASONRY LINTELS

A. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs matching adjacent CMUs in color, texture, and density classification, with reinforcing bars placed as indicated and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.

2.5 BRICK

A. Regional Materials: Brick shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

B. General: Provide shapes indicated and as follows, with exposed surfaces matching finish and color of exposed faces of adjacent units:

1. For ends of sills and caps and for similar applications that would otherwise expose unfinished brick surfaces, provide units without cores or frogs and with exposed surfaces finished.
2. Provide special shapes for applications where stretcher units cannot accommodate special conditions, including those at corners, movement joints, bond beams, sashes, and lintels.
3. Provide special shapes for applications requiring brick of size, form, color, and texture on exposed surfaces that cannot be produced by sawing.
4. Provide special shapes for applications where shapes produced by sawing would result in sawed surfaces being exposed to view.

C. Clay Face Brick: Facing brick complying with ASTM C 216.

1. Grade: SW.
2. Type: FBS.
3. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 3350 psi (23.10 MPa).
4. Initial Rate of Absorption: Less than 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested according to ASTM C 67.
5. Efflorescence: Provide brick that has been tested according to ASTM C 67 and is rated "not effloresced."
6. Surface Coating: Brick with colors or textures produced by application of coatings shall withstand 50 cycles of freezing and thawing according to ASTM C 67 with no observable difference in the applied finish when viewed from 10 feet (3 m).
7. Size (Actual Dimensions): 3-5/8 inches (92 mm) wide by 2-1/4 inches (57 mm) high by 11-5/8 inches (194 mm) long.
8. Use Application: Use where brick is exposed unless otherwise indicated.
9. Color and Texture: Match Architect's samples.

2.6 MORTAR AND GROUT MATERIALS

A. Regional Materials: Aggregate for mortar and grout, cement, and lime shall be extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

B. Portland Cement: ASTM C 150/C 150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

1. Alkali content shall not be more than 0.1 percent when tested according to ASTM C 114.

C. Hydrated Lime: ASTM C 207, Type S.

D. Masonry Cement: ASTM C 91/C 91M.

E. Mortar Pigments: Natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes and complying with ASTM C 979/C 979M. use only pigments with a record of satisfactory performance in masonry mortar.

F. Colored Cement Products: Packaged blend made from portland cement and hydrated lime or masonry cement and mortar pigments, all complying with specified requirements, and containing no other ingredients.

G. Aggregate for Mortar: ASTM C 144.

1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
2. For joints less than 1/4 inch (6 mm) thick, use aggregate graded with 100 percent passing the No. 16 (1.18-mm) sieve.

H. Aggregate for Grout: ASTM C 404.

I. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C 494/C 494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.

J. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with CMUs containing integral water repellent from same manufacturer.

K. Water: Potable.

2.7 REINFORCEMENT

A. Uncoated-Steel Reinforcing Bars: ASTM A 615/A 615M or ASTM A 996/A 996M, Grade 60 (Grade 420).

B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch (3.77-mm) steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.

C. Masonry-Joint Reinforcement, General: ASTM A 951/A 951M.

1. Interior Walls: Hot-dip galvanized carbon steel.
2. Exterior Walls: Hot-dip galvanized carbon steel.
3. Wire Size for Side Rods: 0.148-inch (3.77-mm) diameter.
4. Wire Size for Cross Rods: 0.148-inch (3.77-mm) diameter.
5. Wire Size for Veneer Ties: 0.187-inch (4.76-mm) diameter.
6. Spacing of Cross Rods, Tabs, and Cross Ties: Not more than 16 inches (407 mm) o.c.
7. Provide in lengths of not less than 10 feet (3 m), with prefabricated corner and tee units.

D. Masonry-Joint Reinforcement for Single-Wythe Masonry: Ladder or truss type with single pair of side rods.

E. Masonry-Joint Reinforcement for Multiwythe Masonry:

1. Ladder type with one side rod at each face shell of hollow masonry units more than 4 inches (100 mm) wide, plus one side rod at each wythe of masonry 4 inches (100 mm) wide or less.
2. Tab type, either ladder or truss design, with one side rod at each face shell of backing wythe and with rectangular tabs sized to extend at least halfway through facing wythe, but with at least 5/8-inch (16-mm) cover on outside face.
3. Adjustable (two-piece) type, either ladder or truss design, with one side rod at each face shell of backing wythe and with separate adjustable ties with pintle-and-eye connections having a maximum horizontal play of 1/16 inch (1.5 mm) and maximum vertical adjustment of 1-1/4 inches (32 mm). Size ties to extend at least halfway through facing wythe but with at least 5/8-inch (16-mm) cover on outside face.

F. Masonry-Joint Reinforcement for Veneers Anchored with Seismic Masonry-Veneer Anchors: Single 0.187-inch- (4.76-mm-) diameter, hot-dip galvanized carbon steel continuous wire.

2.8 TIES AND ANCHORS

A. General: Ties and anchors shall extend at least 1-1/2 inches (38 mm) into veneer but with at least a 5/8-inch (16-mm) cover on outside face.

B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:

1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A 82/A 82M, with ASTM A 153/A 153M, Class B-2 coating.
2. Steel Sheet, Galvanized after Fabrication: ASTM A 1008/A 1008M, Commercial Steel, with ASTM A 153/A 153M, Class B coating.
3. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

C. Adjustable Anchors for Connecting to Structural Steel Framing: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

1. Anchor Section for Welding to Steel Frame: Crimped 1/4-inch- (6.35-mm-) diameter, hot-dip galvanized steel wire.
2. Tie Section: Triangular-shaped wire tie made from 0.187-inch- (4.76-mm-) diameter, hot-dip galvanized steel wire.

D. Adjustable Anchors for Connecting to Concrete: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

1. Connector Section: Dovetail tabs for inserting into dovetail slots in concrete and attached to tie section; formed from 0.060-inch- (1.52-mm-) thick steel sheet, galvanized after fabrication.

2. Tie Section: Triangular-shaped wire tie made from 0.187-inch-diameter, hot-dip galvanized steel.

E. Partition Top Anchors: 0.105-inch- (2.66-mm-) thick metal plate with a 3/8-inch- (9.5-mm-) diameter metal rod 6 inches (152 mm) long welded to plate and with closed-end plastic tube fitted over rod that allows rod to move in and out of tube. Fabricate from steel, hot-dip galvanized after fabrication.

F. Rigid Anchors: Fabricate from steel bars 1-1/2 inches (38 mm) wide by 1/4 inch (6.35 mm) thick by 24 inches (610 mm) long, with ends turned up 2 inches (51 mm) or with cross pins unless otherwise indicated.

1. Corrosion Protection: Hot-dip galvanized to comply with ASTM A 153/A 153M.

2.9 EMBEDDED FLASHING MATERIALS

A. Metal Flashing: Provide metal flashing complying with SMACNA's "Architectural Sheet Metal Manual" and as follows:

1. Stainless Steel: ASTM A 240/A 240M or ASTM A 666, Type 304, 0.016 inch (0.40 mm) thick.
2. Copper: ASTM B 370, Temper H00, cold-rolled copper sheet, 16-oz./sq. ft. (4.9-kg/sq. m) weight or 0.0216 inch (0.55 mm) thick or ASTM B 370, Temper H01, high-yield copper sheet, 12-oz./sq. ft. (3.7-kg/sq. m) weight or 0.0162 inch (0.41 mm) thick.
3. Fabricate continuous flashings in sections 96 inches (2400 mm) long minimum, but not exceeding 12 feet (3.7 m). Provide splice plates at joints of formed, smooth metal flashing.
4. Fabricate metal drip edges from stainless steel. Extend at least 3 inches (76 mm) into wall and 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.
5. Fabricate metal expansion-joint strips from stainless steel to shapes indicated.
6. Solder metal items at corners.

B. Flexible Flashing (Contractor’s option for Concealed Flashing: Use one of the following unless otherwise indicated:

1. Copper-Laminated Flashing: 5-oz./sq. ft. (1.5-kg/sq. m) copper sheet bonded between two layers of glass-fiber cloth. Use only where flashing is fully concealed in masonry.

2. EPDM Flashing: Sheet flashing product made from ethylene-propylene-diene terpolymer, complying with ASTM D 4637/D 4367M, 0.040 inch (1.02 mm) thick.

C. Application: Unless otherwise indicated, use the following:

1. Where flashing is indicated to receive counterflashing, use metal flashing.
2. Where flashing is indicated to be turned down at or beyond the wall face, use metal flashing.
3. Where flashing is partly exposed and is indicated to terminate at the wall face, use metal flashing with a drip edge or flexible flashing with a metal drip edge.
4. Where flashing is fully concealed, use metal flashing or flexible flashing.

D. Single-Wythe CMU Flashing System: System of CMU cell flashing pans and interlocking CMU web covers made from UV-resistant, high-density polyethylene. Cell flashing pans have integral weep spouts designed to be built into mortar bed joints and that extend into the cell to prevent clogging with mortar.

E. Solder and Sealants for Sheet Metal Flashings: As specified in Section 076200 "Sheet Metal Flashing and Trim."

F. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

G. Termination Bars for Flexible Flashing: Stainless-steel sheet 0.019 inch by 1-1/2 inches (0.48 mm by 38 mm) with a 3/8 inch (10-mm) sealant flange at top.

2.10 MISCELLANEOUS MASONRY ACCESSORIES

A. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene.

B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D 226/D 226M, Type I (No. 15 asphalt felt).

D. Weep/Cavity Vent Products: Use the following unless otherwise indicated:

1. Cellular Plastic Weep/Vent: One-piece, flexible extrusion made from UV-resistant polypropylene copolymer, full height and width of head joint and depth 1/8 inch (3 mm) less than depth of outer wythe, in color selected from manufacturer's standard.

E. Cavity Drainage Material: Free-draining mesh, made from polymer strands that will not degrade within the wall cavity.

1. Configuration: Provide one of the following:

    a. Strips, full depth of cavity and 10 inches (250 mm) high, with dovetail-shaped notches 7 inches (175 mm) deep that prevent clogging with mortar droppings.

2.11 MORTAR AND GROUT MIXES

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.

1. Do not use calcium chloride in mortar or grout.
2. Use portland cement-lime or masonry cement mortar unless otherwise indicated.
3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.

B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

C. Mortar for Unit Masonry: Comply with ASTM C 270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated.

1. For masonry below grade or in contact with earth, use Type M.
2. For reinforced masonry, use Type S.
3. For exterior, above-grade, load-bearing and nonload-bearing walls and parapet walls; for interior load-bearing walls; for interior nonload-bearing partitions; and for other applications where another type is not indicated, use Type N.

D. Pigmented Mortar: Use colored cement product or select and proportion pigments with other ingredients to produce color required. Do not add pigments to colored cement products.

1. Pigments shall not exceed 10 percent of portland cement by weight.

E. Grout for Unit Masonry: Comply with ASTM C 476.

1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602/ACI 530.1/ASCE 6 for dimensions of grout spaces and pour height.
2. Proportion grout in accordance with ASTM C 476, paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi (14 MPa).
3. Provide grout with a slump of 8 to 11 inches (200 to 280 mm) as measured according to ASTM C 143/C 143M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
2. Verify that foundations are within tolerances specified.
3. Verify that reinforcing dowels are properly placed.
4. Verify that substrates are free of substances that impair mortar bond.

B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Thickness: Build cavity and composite walls and other masonry construction to full thickness shown. Build single-wythe walls to actual widths of masonry units, using units of widths indicated.

B. Build chases and recesses to accommodate items specified in this and other Sections.

C. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.

D. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

E. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures. Mix units from several pallets or cubes as they are placed.

F. Wetting of Brick: Wet brick before laying if initial rate of absorption exceeds 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested according to ASTM C 67. Allow units to absorb water so they are damp but not wet at time of laying.

3.3 TOLERANCES

A. Dimensions and Locations of Elements:

1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch (12 mm) or minus 1/4 inch (6 mm).
2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch (12 mm).
3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch (6 mm) in a story height or 1/2 inch (12 mm) total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
3. For vertical lines and surfaces, do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet ((6 mm in 3 m),) or 1/2-inch (12-mm) maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch (1.5 mm) except due to warpage of masonry units within tolerances specified for warpage of units.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm), with a maximum thickness limited to 1/2 inch (12 mm).
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3 mm).
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (9 mm) or minus 1/4 inch (6 mm).
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm). Do not vary from adjacent bed-joint and head-joint thicknesses by more than 1/8 inch (3 mm).
5. For exposed bed joints and head joints of stacked bond, do not vary from a straight line by more than 1/16 inch (1.5 mm) from one masonry unit to the next.

3.4 LAYING MASONRY WALLS

A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns,

and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.

C. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than 4 inches (100 mm)]. Bond and interlock each course of each wythe at corners. Do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.

D. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.

E. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.

F. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.

G. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below, and rod mortar or grout into core.

H. Fill cores in hollow CMUs with grout 24 inches (600 mm) under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.

I. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.

1. Install compressible filler in joint between top of partition and underside of structure above.
2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors and push tubes down into grout to provide 1/2-inch (13-mm) clearance between end of anchor rod and end of tube. Space anchors 48 inches (1200 mm) o.c. unless otherwise indicated.
3. At fire-rated partitions, treat joint between top of partition and underside of structure above to comply with Section 078443 "Joint Firestopping."

3.5 MORTAR BEDDING AND JOINTING

A. Lay hollow brick and CMUs as follows:

1. Bed face shells in mortar and make head joints of depth equal to bed joints.

2. Bed webs in mortar in all courses of piers, columns, and pilasters.
3. Bed webs in mortar in grouted masonry, including starting course on footings.
4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.
5. Fully bed units and fill cells with mortar at anchors and ties as needed to fully embed anchors and ties in mortar.

B. Lay solid masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

C. Set stone and precast concrete trim units in full bed of mortar with full vertical joints. Fill dowel, anchor, and similar holes.

1. Clean soiled surfaces with fiber brush and soap powder and rinse thoroughly with clear water.
2. Wet joint surfaces thoroughly before applying mortar.
3. Rake out mortar joints for pointing with sealant.

D. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

E. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.

F. Cut joints flush where indicated to receive cavity wall insulation or air barriers unless otherwise indicated.

3.6 ANCHORED MASONRY VENEERS

A. Anchor masonry veneers to concrete and masonry backup with seismic masonry-veneer anchors to comply with the following requirements:

1. Fasten screw-attached and seismic anchors to concrete and masonry backup with metal fasteners of type indicated. Use two fasteners unless anchor design only uses one fastener.
2. Embed tie sections in masonry joints.
3. Locate anchor sections to allow maximum vertical differential movement of ties up and down.
4. Space anchors as indicated, but not more than 16 inches (406 mm) o.c. vertically and 25 inches (635 mm) o.c. horizontally, with not less than one anchor for each 2.67 sq. ft. (0.25 sq. m) of wall area. Install additional anchors within 12 inches (305 mm) of openings and at intervals, not exceeding 36 inches (914 mm), around perimeter.

B. Provide not less than 2 inches (50 mm) of airspace between back of masonry veneer and face of insulation.

1. Keep airspace clean of mortar droppings and other materials during construction. Bevel beds away from airspace, to minimize mortar protrusions into airspace. Do not attempt to trowel or remove mortar fins protruding into airspace.

3.7 MASONRY-JOINT REINFORCEMENT

A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (150 mm).

1. Space reinforcement not more than 16 inches (406 mm) o.c.
2. Space reinforcement not more than 8 inches (203 mm) o.c. in foundation walls and parapet walls.
3. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings.

B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.

C. Provide continuity at wall intersections by using prefabricated T-shaped units.

D. Provide continuity at corners by using prefabricated L-shaped units.

3.8 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:

1. Provide an open space not less than 1/2 inch (13 mm) wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
3. Space anchors as indicated, but not more than 24 inches (610 mm) o.c. vertically and 36 inches (915 mm) o.c. horizontally.

3.9 CONTROL AND EXPANSION JOINTS

A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.

B. Form control joints in concrete masonry as follows:

1. Install preformed control-joint gaskets designed to fit standard sash block.

C. Form expansion joints in brick as follows:

1. Form open joint full depth of brick wythe and of width indicated, but not less than 3/8 inch (10 mm) for installation of sealant and backer rod specified in Section 079200 "Joint Sealants."

D. Provide horizontal, pressure-relieving joints by either leaving an airspace or inserting a compressible filler of width required for installing sealant and backer rod specified in Section 079200 "Joint Sealants," but not less than 3/8 inch (10 mm).

1. Locate horizontal, pressure-relieving joints beneath shelf angles supporting masonry.

3.10 LINTELS

A. Install steel lintels where indicated.

B. Provide masonry lintels where shown and where openings of more than 12 inches (305 mm) for brick-size units and 24 inches (610 mm) for block-size units are shown without structural steel or other supporting lintels.

C. Provide minimum bearing of 8 inches (200 mm) at each jamb unless otherwise indicated.

3.11 FLASHING, WEEP HOLES, AND CAVITY VENTS

A. General: Install embedded flashing and weep holes in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated. Install cavity vents at shelf angles, ledges, and other obstructions to upward flow of air in cavities, and where indicated.

B. Install flashing as follows unless otherwise indicated:

1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.
2. At multiwythe masonry walls, including cavity walls, extend flashing through outer wythe, turned up a minimum of 8 inches (200 mm), and through inner wythe to within 1/2 inch (13 mm) of the interior face of wall in exposed masonry. Where interior face of wall is to receive furring or framing, carry flashing completely through inner wythe and turn flashing up approximately 2 inches (50 mm) on interior face.
3. At lintels and shelf angles, extend flashing a minimum of 6 inches (150 mm) into masonry at each end. At heads and sills, extend flashing 6 inches (150 mm) at ends and turn up not less than 2 inches (50 mm) to form end dams.
4. Interlock end joints of ribbed sheet metal flashing by overlapping ribs not less than 1-1/2 inches (38 mm) or as recommended by flashing manufacturer, and

seal lap with elastomeric sealant complying with requirements in Section 079200 "Joint Sealants" for application indicated.

5. Install metal drip edges with ribbed sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 079200 "Joint Sealants" for application indicated.
6. Install metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal drip edge.

C. Install single-wythe CMU flashing system in bed joints of CMU walls where indicated to comply with manufacturer's written instructions. Install CMU cell pans with upturned edges located below face shells and webs of CMUs above and with weep spouts aligned with face of wall. Install CMU web covers so that they cover upturned edges of CMU cell pans at CMU webs and extend from face shell to face shell.

D. Install reglets and nailers for flashing and other related construction where they are shown to be built into masonry.

E. Install weep holes in exterior wythes and veneers in head joints of first course of masonry immediately above embedded flashing.

1. Use specified weep/cavity vent products to form weep holes.
2. Use wicking material to form weep holes above flashing under brick sills. Turn wicking down at lip of sill to be as inconspicuous as possible.
3. Space weep holes 24 inches (600 mm) o.c. unless otherwise indicated.

F. Place cavity drainage material in cavities to comply with configuration requirements for cavity drainage material in "Miscellaneous Masonry Accessories" Article.

G. Install cavity vents in head joints in exterior wythes at spacing indicated. Use specified weep/cavity vent products to form cavity vents.

1. Close cavities off vertically and horizontally with blocking in manner indicated. Install through-wall flashing and weep holes above horizontal blocking.

3.12 REINFORCED UNIT MASONRY INSTALLATION

A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.

1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and that of other loads that may be placed on them during construction.

B. Placing Reinforcement: Comply with requirements in TMS 602/ACI 530.1/ASCE 6.

C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.

1. Comply with requirements in TMS 602/ACI 530.1/ASCE 6 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
2. Limit height of vertical grout pours to not more than 60 inches (1520 mm).

3.13 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.

B. Inspections: Special inspections according to Level C in TMS 402/ACI 530/ASCE 5.

1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.
2. Place grout only after inspectors have verified compliance of grout spaces and of grades, sizes, and locations of reinforcement.
3. Place grout only after inspectors have verified proportions of site-prepared grout.

C. Testing Prior to Construction: One set of tests.

D. Testing Frequency: One set of tests for each 5000 sq. ft. (464 sq. m) of wall area or portion thereof.

E. Clay Masonry Unit Test: For each type of unit provided, according to ASTM C 67 for compressive strength.

F. Concrete Masonry Unit Test: For each type of unit provided, according to ASTM C 140 for compressive strength.

G. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, according to ASTM C 780.

H. Mortar Test (Property Specification): For each mix provided, according to ASTM C 780. Test mortar for mortar air content and compressive strength.

I. Grout Test (Compressive Strength): For each mix provided, according to ASTM C 1019.

J. Prism Test: For each type of construction provided, according to ASTM C 1314 at 7 days and at 28 days.

3.14 REPAIRING, POINTING, AND CLEANING

A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.

B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.

C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.

D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:

1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
3. Clean brick by bucket-and-brush hand-cleaning method described in BIA Technical Notes 20.
4. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.

3.15 MASONRY WASTE DISPOSAL

A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.

B. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.

1. Crush masonry waste to less than 4 inches (100 mm) in each dimension.
2. Mix masonry waste with at least two parts of specified fill material for each part of masonry waste. Fill material is specified in Section 312000 "Earth Moving."
3. Do not dispose of masonry waste as fill within 18 inches (450 mm) of finished grade.

C. Masonry Waste Recycling: Return broken CMUs not used as fill to manufacturer for recycling.

D. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

END OF SECTION 042000

SECTION 061053 - MISCELLANEOUS ROUGH CARPENTRY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Rooftop equipment bases and support curbs.
2. Wood blocking and nailers.
3. Plywood backing panels.

1.3 DEFINITIONS

A. Boards or Strips: Lumber of less than 2 inches nominal (38 mm actual) size in least dimension.

B. Dimension Lumber: Lumber of 2 inches nominal (38 mm actual) or greater size but less than 5 inches nominal (114 mm actual) size in least dimension.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
3. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.

4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

B. LEED Submittals:

1. Product Data for Credit: For adhesives, documentation including printed statement of VOC content.

1.5 INFORMATIONAL SUBMITTALS

A. Evaluation Reports: For the following, from ICC-ES:

1. Preservative-treated wood.
2. Fire-retardant-treated wood.
3. Power-driven fasteners.
4. Post-installed anchors.
5. Metal framing anchors.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant-treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Stack lumber flat with spacers beneath and between each bundle to provide air circulation. Protect lumber from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

A. Regional Materials: Dimension lumber shall be manufactured within 500 miles (800 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

B. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.

1. Factory mark each piece of lumber with grade stamp of grading agency.
2. Dress lumber, S4S, unless otherwise indicated.

C. Maximum Moisture Content of Lumber: 15 percent.

2.2 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with ground, Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.

1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.

B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or does not comply with requirements for untreated material.

C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

D. Application: Treat items indicated on Drawings, and the following:

1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
2. Wood sills, sleepers, blocking, stripping, and similar concealed members in contact with masonry or concrete.
3. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
4. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
5. Wood floor plates that are installed over concrete slabs-on-grade.

2.3 FIRE-RETARDANT-TREATED MATERIALS

A. General: Where fire-retardant-treated materials are required, and at all interior locations, materials shall comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.

B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested according to ASTM E 84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet (3.2 m) beyond the centerline of the burners at any time during the test.

1. Treatment shall not promote corrosion of metal fasteners.
2. Exterior Type: Treated materials shall comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering according to ASTM D 2898. Use for exterior locations and where indicated.
3. Interior Type A: Treated materials shall have a moisture content of 28 percent or less when tested according to ASTM D 3201 at 92 percent relative humidity. Use where exterior type is not indicated.
4. Design Value Adjustment Factors: Treated lumber shall be tested according to ASTM D 5664, and design value adjustment factors shall be calculated according to ASTM D 6841.

C. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent.

D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency.

E. Application: Treat items indicated on Drawings, and the following:

1. Concealed blocking.
2. Roof framing and blocking.
3. Wood cants, nailers, curbs, equipment support bases, blocking, and similar members in connection with roofing.
4. Plywood backing panels.

2.4 DIMENSION LUMBER

A. Construction, Stud, or No. 3 grade of any of the following species:

1. Hem-fir (north); NLGA.
2. Southern pine; SPIB.
3. Douglas fir-larch; WCLIB or WWPA.
4. Southern pine or mixed southern pine; SPIB.
5. Spruce-pine-fir; NLGA.
6. Douglas fir-south; WWPA.
7. Hem-fir; WCLIB or WWPA.
8. Douglas fir-larch (north); NLGA.
9. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.

B. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.

C. For furring strips for installing finished architectural woodwork, select boards with no knots capable of producing bent over nails and damage to panels.

2.5 PLYWOOD BACKING PANELS

A. Equipment Backing Panels: Plywood, DOC PS 1, Exterior, A-C, fire-retardant treated, in thickness indicated or, if not indicated, not less than 3/4-inch (19-mm) nominal thickness.

2.6 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.

1. Where carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.

B. Nails, Brads, and Staples: ASTM F 1667.

C. Screws for Fastening to Metal Framing: ASTM C 1002, length as recommended by screw manufacturer for material being fastened.

D. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

E. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01 or ICC-ES AC58 as appropriate for the substrate.

1. Material: Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.

2.7 METAL FRAMING ANCHORS

A. Galvanized-Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A 653/A 653M, G60 (Z180) coating designation.

1. Use for interior locations unless otherwise indicated.

B. Hot-Dip, Heavy-Galvanized Steel Sheet: ASTM A 653/A 653M; Structural Steel (SS), high-strength low-alloy steel Type A (HSLAS Type A), or high-strength low-alloy steel Type B (HSLAS Type B); G185 (Z550) coating designation; and not less than 0.036 inch (0.9 mm) thick.

1. Use for wood-preservative-treated lumber for exterior applications (unless noted otherwise), and where indicated.

2.8 MISCELLANEOUS MATERIALS

A. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber or rubberized-asphalt compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.025 inch (0.6 mm).

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Framing Standard: Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.

B. Set carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit carpentry accurately to other construction. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.

C. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels.

D. Install metal framing anchors to comply with manufacturer's written instructions. Install fasteners through each fastener hole.

E. Do not splice structural members between supports unless otherwise indicated.

F. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.

1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches (406 mm) o.c.

G. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

H. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

1. Use inorganic boron for items that are continuously protected from liquid water.
2. Use copper naphthenate for items not continuously protected from liquid water.

I. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.

J. Securely attach carpentry work to substrate by anchoring and fastening as indicated, complying with the following:

1. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code.
2. ICC-ES evaluation report for fastener.

K. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

3.2 WOOD BLOCKING AND NAILER INSTALLATION

A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.

3.3 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect miscellaneous rough carpentry from weather. If, despite protection, miscellaneous rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION 061053

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SECTION 061600 - SHEATHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Wall sheathing.

B. Related Requirements:

1. Section 061053 "Miscellaneous Rough Carpentry" for plywood backing panels.
2. Section 072500 "Weather Barriers" for water-resistive barrier applied over wall sheathing.

1.3 Action Submittals:

A. For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

B. LEED Submittals:

1. Certificates for [**Credit MR 6**] [**Credit MR 7**]: Chain-of-custody certificates indicating that products specified to be made from certified wood comply with forest certification requirements. Include documentation that manufacturer is certified for chain of custody by an FSC-accredited certification body. Include statement indicating cost for each certified wood product.
2. Product Data for Credit IEQ 4.1: For adhesives, documentation including printed statement of VOC content.
3. Laboratory Test Reports for Credit IEQ 4.1: For adhesives, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. Product Data for Credit IEQ 4.4: For composite wood products, documentation indicating that product contains no urea formaldehyde.

5. Laboratory Test Reports for Credit IEQ 4.4: For composite-wood products, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

1.4 DELIVERY, STORAGE, AND HANDLING

A. Stack panels flat with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Resistance Ratings: As tested according to ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.2 PARAPET SHEATHING

A. Cementitious Backer Units: ASTM C1325, Type A.

1. Thickness: As indicated.

2.3 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.

1. For parapet and wall sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.

B. Screws for Fastening Sheathing to Cold-Formed Metal Framing: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing to be attached.

2.4 SHEATHING JOINT-AND-PENETRATION TREATMENT MATERIALS

A. Sealant for Cementitious Sheathing: Silicone emulsion sealant complying with ASTM C 834, compatible with sheathing tape and sheathing and recommended by tape and sheathing manufacturers for use with cementitious sheathing tape and for covering exposed fasteners.

1. Sheathing Tape: Self-adhering glass-fiber tape, minimum 2 inches (50 mm) wide, 10 by 10 or 10 by 20 threads/inch (390 by 390 or 390 by 780 threads/m), of type recommended by sheathing and tape manufacturers for use with silicone emulsion sealant in sealing joints in glass-mat gypsum sheathing and with a history of successful in-service use.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.

B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.

C. Securely attach to substrate by fastening as indicated, complying with the following:

1. Table 2304.9.1, "Fastening Schedule," in the ICC's International Building Code.
2. ICC-ES evaluation report for fastener.

D. Coordinate parapet and wall sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.

E. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.

F. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.2 CEMENTITIOUS BACKER UNIT INSTALLATION

A. Install panels and treat joints according to ANSI A108.11 and manufacturer's written instructions for type of application indicated.

END OF SECTION 061600

SECTION 064116 - PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Plastic-laminate-faced architectural cabinets.

B. Related Requirements:

1. Section 061053 "Miscellaneous Rough Carpentry" for wood furring, blocking, shims, and hanging strips required for installing cabinets and concealed within other construction before cabinet installation.
2. Section 123661 “Simulated Stone”.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including high-pressure decorative laminate, adhesive for bonding plastic laminate and cabinet hardware and accessories.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regionally manufactured materials. Include statement indicating cost for each regionally manufactured material.

    a. Include statement indicating location of manufacturer and distance to Project for each regionally manufactured material.
3. Product Data for Credit IEQ 4.4: For adhesives and composite wood products, documentation indicating that products contain no urea formaldehyde.

C. Shop Drawings: Show location of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components.

1. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in other Sections.
2. Show locations and sizes of cutouts and holes for electrical switches and outlets and other items installed in architectural plastic-laminate cabinets.

D. Samples for Verification:

1. Plastic laminates, 8 by 10 inches (200 by 250 mm), for each type, color, pattern, and surface finish, with one sample applied to core material and specified edge material applied to one edge.

2. Exposed cabinet hardware and accessories, one unit for each type and finish.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and fabricator.

B. Product Certificates: For each type of product.

C. Evaluation Reports: For fire-retardant-treated materials, from ICC-ES.

1.5 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.

B. Installer Qualifications: Fabricator of products.

C. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant-treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver cabinets until painting and similar operations that could damage woodwork have been completed in installation areas. If cabinets must be stored in other than installation areas, store only in areas where environmental conditions comply with requirements specified in "Field Conditions" Article.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not deliver or install cabinets until building is enclosed, wet work is complete, and HVAC system is operating and maintaining temperature and relative humidity at occupancy levels during the remainder of the construction period.

B. Field Measurements: Where cabinets are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

C. Established Dimensions: Where cabinets are indicated to fit to other construction, establish dimensions for areas where cabinets are to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

1.8 COORDINATION

A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections to ensure that cabinets can be supported and installed as indicated.

PART 2 - PRODUCTS

2.1 PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS

A. Quality Standard: Unless otherwise indicated, comply with the "Architectural Woodwork Standards" for grades of architectural plastic-laminate cabinets indicated for construction, finishes, installation, and other requirements.

1. The Contract Documents contain selections chosen from options in the quality standard and additional requirements beyond those of the quality standard. Comply with those selections and requirements in addition to the quality standard.

B. Grade: Premium.

C. Regional Materials: Plastic-laminate cabinets shall be manufactured within 100 miles of Project site.

D. Certified Wood: Plastic-laminate cabinets shall be made from wood products certified as "FSC Pure" or "FSC Mixed Credit" according to FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship," and FSC STD-40-004, "FSC Standard for Chain of Custody Certification."

E. Type of Construction: Frameless.

F. Cabinet, Door, and Drawer Front Interface Style: Flush overlay.

G. High-Pressure Decorative Laminate: NEMA LD 3, grades as indicated or if not indicated, as required by woodwork quality standard.

H. Laminate Cladding for Exposed Surfaces:

1. Horizontal Surfaces: Grade HGS.
2. Postformed Surfaces: Grade HGP.
3. Vertical Surfaces: Grade HGS.
4. Edges: Grade HGS.
5. Pattern Direction: Vertically for drawer fronts, doors, and fixed panels.

I. Materials for Semiexposed Surfaces:

1. Surfaces Other Than Drawer Bodies: High-pressure decorative laminate, NEMA LD 3, Grade VGS.

   a. Edges of Plastic-Laminate Shelves: PVC edge banding, 0.12 inch (3 mm) thick, matching laminate in color, pattern, and finish.
   b. For semiexposed backs of panels with exposed plastic-laminate surfaces, provide surface of high-pressure decorative laminate, NEMA LD 3, Grade VGS.

2. Drawer Sides and Backs: Solid-hardwood lumber.
3. Drawer Bottoms: Hardwood plywood.

J. Concealed Backs of Panels with Exposed Plastic-Laminate Surfaces: High-pressure decorative laminate, NEMA LD 3, Grade BKL.

K. Colors, Patterns, and Finishes: Provide materials and products that result in colors and textures of exposed laminate surfaces complying with the following requirements:

1. As indicated by laminate manufacturer's designations.

2.2 WOOD MATERIALS

A. Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of woodwork and quality grade specified unless otherwise indicated.

1. Wood Moisture Content: 5 to 10 percent.

B. Composite Wood and Agrifiber Products: Provide materials that comply with requirements of referenced quality standard for each type of woodwork and quality grade specified unless otherwise indicated.

1. Medium-Density Fiberboard: ANSI A208.2, Grade 130, made with binder containing no urea formaldehyde.
2. Particleboard: ANSI A208.1, Grade M-2, made with binder containing no urea formaldehyde.
3. Softwood Plywood: DOC PS 1, medium-density overlay.

2.3 CABINET HARDWARE AND ACCESSORIES

A. General: Provide cabinet hardware and accessory materials associated with architectural cabinets except for items specified in Section 087111 "Door Hardware (Descriptive Specification)."

B. Frameless Concealed Hinges (European Type): BHMA A156.9, B01602, 170 degrees of opening, self-closing.

C. Back-Mounted Pulls: BHMA A156.9, B02011.

D. Pulls: Back mounted, cast solid metal, 5 inches long. Jeffrey Alexander. Sonoma Collection, #4128, Satin Nickel finish, or equal.

E. Catches: Magnetic catches, BHMA A156.9, B03141.

F. Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081.

G. Drawer Slides: BHMA A156.9.

1. Grade 1HD-100 and Grade 1HD-200: Side mounted; full-extension type; zinc-plated-steel ball-bearing slides.
2. For drawers not more than 3 inches (75 mm) high and not more than 24 inches (600 mm) wide, provide Grade 1.
3. For drawers more than 3 inches (75 mm) high but not more than 6 inches (150 mm) high and not more than 24 inches (600 mm) wide, provide Grade 1HD-100.
4. For drawers more than 6 inches (150 mm) high or more than 24 inches (600 mm) wide, provide Grade 1HD-200.

H. Door Locks: BHMA A156.11, E07121 cylinder lock compatible with 7-pin Best core provided under Section 087100 “Door Hardware”.

I. Door and Drawer Silencers: BHMA A156.16, L03011.

J. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with BHMA A156.18 for BHMA finish number indicated.

1. Satin Chromium Plated: BHMA 626 for brass or bronze base; BHMA 652 for steel base.

K. For concealed hardware, provide manufacturer's standard finish that complies with product class requirements in BHMA A156.9.

2.4 MISCELLANEOUS MATERIALS

A. Furring, Blocking, Shims, and Hanging Strips: Fire-retardant-treated softwood lumber, kiln dried to less than 15 percent moisture content.

B. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide metal expansion sleeves or expansion bolts for post-installed anchors. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.

C. Adhesives: Do not use adhesives that contain urea formaldehyde.

D. Adhesive for Bonding Plastic Laminate: Unpigmented contact cement.

1. Adhesive for Bonding Edges: Hot-melt adhesive or adhesive specified above for faces.

2.5 FABRICATION

A. Sand fire-retardant-treated wood lightly to remove raised grain on exposed surfaces before fabrication.

B. Fabricate cabinets to dimensions, profiles, and details indicated.

C. Complete fabrication, including assembly and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

1. Trial fit assemblies at fabrication shop that cannot be shipped completely assembled. Install dowels, screws, bolted connectors, and other fastening devices that can be removed after trial fitting. Verify that various parts fit as intended and check measurements of assemblies against field measurements before disassembling for shipment.

D. Shop-cut openings to maximum extent possible to receive hardware, appliances, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

PART 3 - EXECUTION

3.1 PREPARATION

A. Before installation, condition cabinets to average prevailing humidity conditions in installation areas.

B. Before installing cabinets, examine shop-fabricated work for completion and complete work as required.

3.2 INSTALLATION

A. Grade: Install cabinets to comply with same grade as item to be installed.

B. Assemble cabinets and complete fabrication at Project site to the extent that it was not completed in the shop.

C. Install cabinets level, plumb, true, and straight. Shim as required with concealed shims. Install level and plumb to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm).

D. Scribe and cut cabinets to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.

E. Anchor cabinets to anchors or blocking built in or directly attached to substrates. Secure with countersunk, concealed fasteners and blind nailing. Use fine finishing nails or finishing screws for exposed fastening, countersunk and filled flush with woodwork.

1. Use filler matching finish of items being installed.

F. Cabinets: Install without distortion so doors and drawers fit openings properly and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.

1. Install cabinets with no more than 1/8 inch in 96-inch (3 mm in 2400-mm) sag, bow, or other variation from a straight line.
2. Fasten wall cabinets through back, near top and bottom, and at ends not more than 16 inches (400 mm) o.c. with No. 10 wafer-head screws sized for not less than 1-1/2-inch (38-mm) penetration into wood framing, blocking, or hanging strips or No. 10 wafer-head sheet metal screws through metal backing or metal framing behind wall finish.

3.3 ADJUSTING AND CLEANING

A. Repair damaged and defective cabinets, where possible, to eliminate functional and visual defects; where not possible to repair, replace woodwork. Adjust joinery for uniform appearance.

B. Clean, lubricate, and adjust hardware.

C. Clean cabinets on exposed and semiexposed surfaces.

END OF SECTION 064116

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SECTION 072100 - THERMAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Extruded polystyrene foam-plastic board.
2. Glass-fiber blanket.

B. Related Requirements:

1. Section 042000 "Unit Masonry" for insulation installed in masonry cells.
2. Section 061600 "Sheathing" for foam-plastic board sheathing installed directly over wood or steel framing.
3. Section 075423 "Thermoplastic Polyolefin (TPO) Roofing" for insulation specified as part of roofing construction.
4. Section 092900 "Gypsum Board" for sound attenuation blanket used as acoustic insulation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Low-emitting product certification.

1.4 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each product, for tests performed by a qualified testing agency.

B. Evaluation Reports: For foam-plastic insulation, from ICC-ES.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

B. Protect foam-plastic board insulation as follows:

1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site until just before installation time.
3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 - PRODUCTS

2.1 EXTRUDED POLYSTYRENE FOAM-PLASTIC BOARD

A. Extruded polystyrene boards in this article are also called "XPS boards." Roman numeral designators in ASTM C 578 are assigned in a fixed random sequence, and their numeric order does not reflect increasing strength or other characteristics.

B. Extruded Polystyrene Board, Type IV: ASTM C 578, Type IV, 25-psi (173-kPa) minimum compressive strength; unfaced; maximum flame-spread and smoke-developed indexes of 25 and 450, respectively, per ASTM E 84.

1. For “Z” furring, cavity wall, and below grade vertical surfaces.

2. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

C. Extruded Polystyrene Board, Type VII, Drainage Panels: ASTM C 578, Type VII, 60-psi (414-kPa) minimum compressive strength; maximum flame-spread and smoke-developed indexes of 25 and 450, respectively, per ASTM E 84.

1. For below grade horizontal slab surfaces.

2.2 GLASS-FIBER BLANKET

A. Sustainability Requirements: Provide glass-fiber blanket insulation as follows:

1. Low Emitting: Insulation tested according to ASTM D 5116 and shown to emit less than 0.05-ppm formaldehyde.

B. Glass-Fiber Blanket, Unfaced: ASTM C 665, Type I; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.

1. For metal stud cavaties.

2.3 GLASS-FIBER BOARD

A. Glass-Fiber Board, Faced: ASTM C 612, Type IA; faced on one side with foil-scrim-kraft or foil-scrim-polyethylene vapor retarder, with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84. Nominal density of 4.25 lb/cu. ft. (68 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C).

1. For curtain wall spandrels.

2.4 MINERAL-WOOL BOARD

A. Mineral-Wool Board, Types IA and IB, Unfaced Safing: ASTM C 612, Types IA and IB; with maximum flame-spread and smoke-developed indexes of 15 and zero, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics. Nominal density of 4 lb/cu. ft. (64 kg/cu. m).

1. For use in conjunction with firestopping systems.

2.5 INSULATION FASTENERS

A. Adhesively Attached, Spindle-Type Anchors: Plate welded to projecting spindle; capable of holding insulation of specified thickness securely in position with self-locking washer in place.

1. Plate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.762 mm) thick by 2 inches (50 mm) square.
2. Spindle: Copper-coated, low-carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation.

B. Adhesively Attached, Angle-Shaped, Spindle-Type Anchors: Angle welded to projecting spindle; capable of holding insulation of specified thickness securely in position with self-locking washer in place.

1. For curtainwall spandrels.
2. Angle: Formed from 0.030-inch- (0.762-mm-) thick, perforated, galvanized carbon-steel sheet with each leg 2 inches (50 mm) square.

3. Spindle: Copper-coated, low-carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation.

C. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrate without damaging insulation, fasteners, or substrates.

2.6 ACCESSORIES

A. Insulation for Miscellaneous Voids:

1. Glass-Fiber Insulation: ASTM C 764, Type II, loose fill; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E 84.
2. Spray Polyurethane Foam Insulation: ASTM C 1029, Type II, closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84.

B. Adhesive for Bonding Insulation: Product compatible with insulation and air and water barrier materials, and with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean substrates of substances that are harmful to insulation, including removing projections capable of puncturing insulation or vapor retarders, or that interfere with insulation attachment.

3.2 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products and applications.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.

C. Extend insulation to envelop entire area to be insulated. Fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

D. Provide sizes to fit applications and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units unless multiple layers are otherwise shown or required to make up total thickness or to achieve R-value.

3.3 INSTALLATION OF SLAB INSULATION

A. On vertical slab edge and foundation surfaces, set insulation units using manufacturer's recommended adhesive according to manufacturer's written instructions.

1. If not otherwise indicated, extend insulation a minimum of 24 inches (610 mm) below exterior grade line.

B. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

1. If not otherwise indicated, extend insulation a minimum of 24 inches (610 mm) in from exterior walls.

3.4 INSTALLATION OF FOUNDATION WALL INSULATION

A. Butt panels together for tight fit.

B. Adhesive Installation: Install with adhesive or press into tacky waterproofing or dampproofing according to manufacturer's written instructions.

3.5 INSTALLATION OF CAVITY-WALL INSULATION

A. Foam-Plastic Board Insulation: Install pads of adhesive spaced approximately 24 inches (610 mm) o.c. both ways on inside face and as recommended by manufacturer. Fit courses of insulation between wall ties and other obstructions, with edges butted tightly in both directions. Press units firmly against inside substrates.

1. Supplement adhesive attachment of insulation by securing boards with two-piece wall ties designed for this purpose and specified in Section 042000 "Unit Masonry."

3.6 INSTALLATION OF INSULATION IN FRAMED CONSTRUCTION

A. Blanket Insulation: Install in cavities formed by framing members according to the following requirements:

1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill the cavities, provide lengths that will produce a snug fit between ends.
2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
3. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.

4. For metal-framed wall cavities where cavity heights exceed 96 inches (2438 mm), support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.
5. Vapor-Retarder-Faced Blankets: Tape joints and ruptures in vapor-retarder facings, and seal each continuous area of insulation to ensure airtight installation.

    a. Exterior Walls: Set units with facing placed toward interior of construction.

B. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation using the following materials:

1. Glass-Fiber Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft. (40 kg/cu. m).
2. Spray Polyurethane Insulation: Apply according to manufacturer's written instructions.

3.7 INSTALLATION OF CURTAIN-WALL INSULATION

A. Install board insulation in curtain-wall construction according to curtain-wall manufacturer's written instructions.

1. Hold insulation in place by securing metal clips and straps or integral pockets within window frames, spaced at intervals recommended in writing by insulation manufacturer to hold insulation securely in place without touching spandrel glass. Maintain cavity width of dimension indicated on Drawings between insulation and glass.
2. Install insulation to fit snugly without bowing.

3.8 PROTECTION

A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION 072100

SECTION 072726 - FLUID-APPLIED MEMBRANE AIR BARRIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes fluid-applied, vapor-permeable membrane air barriers.

B. Related Requirements:

1. Section 061600 "Sheathing" for wall sheathings and wall sheathing joint-and-penetration treatments.

1.3 DEFINITIONS

A. Air-Barrier Material: A primary element that provides a continuous barrier to the movement of air.

B. Air-Barrier Accessory: A transitional component of the air barrier that provides continuity.

C. Air-Barrier Assembly: The collection of air-barrier materials and accessory materials applied to an opaque wall, including joints and junctions to abutting construction, to control air movement through the wall.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review air-barrier requirements and installation, special details, mockups, air-leakage and bond testing, air-barrier protection, and work scheduling that covers air barriers.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include manufacturer's written instructions for evaluating, preparing, and treating substrate; technical data; and tested physical and performance properties of products.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.2: For air-barrier products, documentation including printed statement of VOC content.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Certificates: From air-barrier manufacturer, certifying compatibility of air barriers and accessory materials with Project materials that connect to or that come in contact with the barrier.

C. Product Test Reports: For each air-barrier assembly, for tests performed by a qualified testing agency.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Mockups: Build mockups to set quality standards for materials and execution.

1. Build integrated mockups of exterior wall assembly as shown on Drawings, incorporating backup wall construction, external cladding, window, storefront, door frame and sill, insulation, ties and other penetrations, and flashing to demonstrate surface preparation, crack and joint treatment, application of air barriers, and sealing of gaps, terminations, and penetrations of air-barrier assembly.

a. If Architect determines mockups do not comply with requirements, reconstruct mockups, and apply air barrier until mockups are approved.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Remove and replace liquid materials that cannot be applied within their stated shelf life.

B. Protect stored materials from direct sunlight.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Apply air barrier within the range of ambient and substrate temperatures recommended by air-barrier manufacturer.

1. Protect substrates from environmental conditions that affect air-barrier performance.
2. Do not apply air barrier to a damp or wet substrate or during snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Source Limitations: Obtain primary air-barrier materials and air-barrier accessories from single source from single manufacturer.

B. VOC Content: 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24) and complying with VOC content limits of authorities having jurisdiction.

2.2 PERFORMANCE REQUIREMENTS

A. General: Air barrier shall be capable of performing as a continuous vapor-permeable air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies shall be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.

B. Air-Barrier Assembly Air Leakage: Maximum 0.04 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft. (0.2 L/s x sq. m of surface area at 75 Pa), when tested according to ASTM E 2357.

2.3 VAPOR-PERMEABLE MEMBRANE AIR-BARRIER

A. Fluid-Applied, Vapor-Permeable Membrane Air Barrier: Elastomeric membrane.

1. Synthetic Polymer Membrane:

a. Basis-of-Design Product: WR Meadows Air-Shield LMP.

2. Physical and Performance Properties:

a. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. (0.02 L/s x sq. m of surface area at 75-Pa) pressure difference; ASTM E 2178.
b. Vapor Permeance: Minimum 10 perms (580 ng/Pa x s x sq. m); ASTM E 96/E 96M.
c. Ultimate Elongation: Minimum 1000 percent; ASTM D 412, Die C.

2.4 ACCESSORY MATERIALS

A. General: Accessory materials recommended by air-barrier manufacturer to produce a complete air-barrier assembly and compatible with primary air-barrier material.

B. Primer: Liquid waterborne primer recommended for substrate by air-barrier material manufacturer.

C. Counterflashing Strip: Modified bituminous, 40-mil- (1.0-mm-) thick, self-adhering sheet consisting of 32 mils (0.8 mm) of rubberized asphalt laminated to an 8-mil- (0.2-mm-) thick, cross-laminated polyethylene film with release liner backing.

D. Joint Reinforcing Strip: Air-barrier manufacturer's glass-fiber-mesh tape.

E. Substrate-Patching Membrane: Manufacturer's standard trowel-grade substrate filler.

F. Adhesive and Tape: Air-barrier manufacturer's standard adhesive and pressure-sensitive adhesive tape.

G. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, 0.0187 inch (0.5 mm) thick, and Series 300 stainless-steel fasteners.

H. Sprayed Polyurethane Foam Sealant: One- or two-component, foamed-in-place, polyurethane foam sealant, 1.5- to 2.0-lb/cu. ft (24- to 32-kg/cu. m) density; flame-spread index of 25 or less according to ASTM E 162; with primer and noncorrosive substrate cleaner recommended by foam sealant manufacturer.

I. Elastomeric Flashing Sheet: ASTM D 2000, minimum 50- to 65-mil- (1.3- to 1.6-mm-) thick, cured sheet neoprene with manufacturer-recommended contact adhesives and lap sealant with aluminum termination bars and stainless-steel fasteners.

J. Joint Sealant: ASTM C 920, single-component, neutral-curing silicone; Class 100/50 (low modulus), Grade NS, Use NT related to exposure, and, as applicable to joint substrates indicated, Use O. Comply with Section 079200 "Joint Sealants."

K. Termination Mastic: Air-barrier manufacturer's standard cold fluid-applied elastomeric liquid; trowel grade.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

1. Verify that substrates are sound and free of oil, grease, dirt, excess mortar, or other contaminants.
2. Verify that concrete has cured and aged for minimum time period recommended by air-barrier manufacturer.
3. Verify that concrete is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
4. Verify that masonry joints are flush and completely filled with mortar.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SURFACE PREPARATION

A. Clean, prepare, treat, and seal substrate according to manufacturer's written instructions. Provide clean, dust-free, and dry substrate for air-barrier application.

B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.

C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.

D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching membrane.

E. Remove excess mortar from masonry ties, shelf angles, and other obstructions.

F. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.

G. Cover gaps in substrate plane and form a smooth transition from one substrate plane to another with stainless-steel sheet mechanically fastened to structural framing to provide continuous support for air barrier.

3.3 JOINT TREATMENT

A. Concrete and Masonry: Prepare, treat, rout, and fill joints and cracks in substrate according to ASTM C 1193 and air-barrier manufacturer's written instructions. Remove dust and dirt from joints and cracks complying with ASTM D 4258 before coating surfaces.

1. Prime substrate and apply a single thickness of air-barrier manufacturer's recommended preparation coat extending a minimum of 3 inches (75 mm) along each side of joints and cracks. Apply a double thickness of fluid air-barrier material and embed a joint reinforcing strip in preparation coat.

B. Gypsum Sheathing: Fill joints greater than 1/4 inch (6 mm) with sealant according to ASTM C 1193 and air-barrier manufacturer's written instructions. Apply first layer of fluid air-barrier material at joints. Tape joints with joint reinforcing strip after first layer is dry. Apply a second layer of fluid air-barrier material over joint reinforcing strip.

3.4 TRANSITION STRIP INSTALLATION

A. General: Install strips, transition strips, and accessory materials according to air-barrier manufacturer's written instructions to form a seal with adjacent construction and maintain a continuous air barrier.

1. Coordinate the installation of air barrier with installation of roofing membrane and base flashing to ensure continuity of air barrier with roofing membrane.

B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by fluid air-barrier material on same day. Reprime areas exposed for more than 24 hours.

1. Prime glass-fiber-surfaced gypsum sheathing with number of prime coats needed to achieve required bond, with adequate drying time between coats.

C. Connect and seal exterior wall air-barrier material continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials.

D. At end of each working day, seal top edge of strips and transition strips to substrate with termination mastic.

E. Apply joint sealants forming part of air-barrier assembly within manufacturer's recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.

F. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Apply modified elastomeric flashing sheet so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate. Maintain 3 inches (75 mm) of full contact over firm bearing to perimeter frames with not less than 1 inch (25 mm) of full contact.

1. Elastomeric Flashing Sheet: Apply adhesive to wall, frame, and flashing sheet. Install flashing sheet and termination bars, fastened at 6 inches (150 mm) o.c. Apply lap sealant over exposed edges and on cavity side of flashing sheet.

G. Fill gaps in perimeter frame surfaces of windows, curtain walls, storefronts, and doors, and miscellaneous penetrations of air-barrier material with foam sealant.

H. Seal strips and transition strips around masonry reinforcing or ties and penetrations with termination mastic.

I. Seal top of through-wall flashings to air barrier with an additional 6-inch- (150-mm-) wide, counterflashing strip.

J. Seal exposed edges of strips at seams, cuts, penetrations, and terminations not concealed by metal counterflashings or ending in reglets with termination mastic.

K. Repair punctures, voids, and deficient lapped seams in strips and transition strips. Slit and flatten fishmouths and blisters. Patch with transition strips extending 6 inches (150 mm) beyond repaired areas in strip direction.

3.5 FLUID AIR-BARRIER MEMBRANE INSTALLATION

A. General: Apply fluid air-barrier material to form a seal with strips and transition strips and to achieve a continuous air barrier according to air-barrier manufacturer's written instructions. Apply fluid air-barrier material within manufacturer's recommended application temperature ranges.

1. Apply primer to substrates at required rate and allow it to dry, if required by manufacturer.
2. Limit priming to areas that will be covered by fluid air-barrier material on same day. Reprime areas exposed for more than 24 hours.
3. Prime glass-fiber-surfaced gypsum sheathing with number of prime coats needed to achieve required bond, with adequate drying time between coats.

B. Membrane Air Barriers: Apply a continuous unbroken air-barrier membrane to substrates according to the following thickness. Apply air-barrier membrane in full contact around protrusions such as masonry ties.

1. Vapor-Permeable Membrane Air Barrier: Total dry film thickness as recommended in writing by manufacturer to meet performance requirements, but not less than 40-mil (1.0-mm) dry film thickness, applied in one or more equal coats.

C. Apply strip and transition strip a minimum of 1 inch (25 mm) onto cured air-barrier material or strip and transition strip over cured air-barrier material overlapping 3 inches (75 mm) onto each surface according to air-barrier manufacturer's written instructions.

D. Do not cover air barrier until it has been tested and inspected by Owner's testing agency.

E. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

3.6 FIELD QUALITY CONTROL

A. Inspections: Air-barrier materials, accessories, and installation are subject to inspection for compliance with requirements. Inspections may include the following:

1. Continuity of air-barrier system has been achieved throughout the building envelope with no gaps or holes.
2. Continuous structural support of air-barrier system has been provided.
3. Masonry and concrete surfaces are smooth, clean, and free of cavities, protrusions, and mortar droppings.
4. Site conditions for application temperature and dryness of substrates have been maintained.
5. Maximum exposure time of materials to UV deterioration has not been exceeded.
6. Surfaces have been primed, if applicable.
7. Laps in strips and transition strips have complied with minimum requirements and have been shingled in the correct direction (or mastic has been applied on exposed edges), with no fishmouths.
8. Termination mastic has been applied on cut edges.
9. Strips and transition strips have been firmly adhered to substrate.
10. Compatible materials have been used.
11. Transitions at changes in direction and structural support at gaps have been provided.
12. Connections between assemblies (air-barrier and sealants) have complied with requirements for cleanliness, surface preparation and priming, structural support, integrity, and continuity of seal.
13. All penetrations have been sealed.

B. Air barriers will be considered defective if they do not pass tests and inspections.

1. Apply additional air-barrier material, according to manufacturer's written instructions, where inspection results indicate insufficient thickness.
2. Remove and replace deficient air-barrier components for retesting as specified above.

C. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.

3.7 CLEANING AND PROTECTION

A. Protect air-barrier system from damage during application and remainder of construction period, according to manufacturer's written instructions.

1. Protect air barrier from exposure to UV light and harmful weather exposure as required by manufacturer. If exposed to these conditions for more than 30 days, remove and replace air barrier or install additional, full-thickness, air-barrier application after repairing and preparing the overexposed membrane according to air-barrier manufacturer's written instructions.

2. Protect air barrier from contact with incompatible materials and sealants not approved by air-barrier manufacturer.

B. Clean spills, stains, and soiling from construction that would be exposed in the completed work using cleaning agents and procedures recommended by manufacturer of affected construction.

C. Remove masking materials after installation.

END OF SECTION 072726

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SECTION 074113.23 - INSULATED METAL ROOF PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulated metal roof panels.

B. Related Sections:

1. Section 074213.19 “Insulated Metal Wall Panels”.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
2. Accessories: Include details of the flashing, trim, and anchorage systems, at a scale of not less than 1-1/2 inches per 12 inches (1:10).

D. Samples for Initial Selection: For each type of metal panel indicated with factory-applied color finishes.

E. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.

1. Metal Panels: 12 inches (305 mm) long by actual panel width. Include clips, fasteners, closures, and other metal panel accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each product, for tests performed by a qualified testing agency.

C. Field quality-control reports.

D. Sample Warranties: For special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panels to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal panels during installation.

1.9 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.10 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

B. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including rupturing, cracking, or puncturing.
b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Solar Reflectance Index: Not less than 78 when calculated according to ASTM E 1980 based on testing identical products by a qualified testing agency.

C. Energy Performance: Provide roof panels that are listed on the EPA/DOE's ENERGY STAR "Roof Product List" for low-slope roof products.

D. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 72:

1. Wind Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.
3. Deflection Limits: For wind loads, no greater than 1/180 of the span.

E. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) when tested according to ASTM E 1680 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa).

F. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 1646 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa).

2. Uplift Rating: UL 60.

G. FM Global Listing: Provide metal roof panels and component materials that comply with requirements in FM Global 4471 as part of a panel roofing system and that are listed in FM Global's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.

1. Fire/Windstorm Classification: Class 1A-60.
2. Hail Resistance: MH.

H. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 FOAMED-INSULATION-CORE METAL ROOF PANELS

A. General: Provide factory-formed and -assembled metal roof panels fabricated from two sheets of metal with insulation core foamed in place during fabrication with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.

1. Panel Performance:

a. Flatwise Tensile Strength: 30 psi (200 kPa) when tested according to ASTM C 297/C 297M.
b. Humid Aging: Volume increase not greater than 6.0 percent and no delamination or metal corrosion when tested for seven days at 140 deg F (60 deg C) and 100 percent relative humidity according to ASTM D 2126.
c. Heat Aging: Volume increase not greater than 2.0 percent and no delamination, surface blistering, or permanent bowing when tested for seven days at 200 deg F (93 deg C) according to ASTM D 2126.
d. Cold Aging: Volume decrease not more than 1.0 percent and no delamination, surface blistering, or permanent bowing when tested for seven days at minus 20 deg F (29 deg C) according to ASTM D 2126.
e. Fatigue: No evidence of delamination, core cracking, or permanent bowing when tested to a 20-lbf/sq. ft. (958-kPa) positive and negative wind load and with deflection of L/180 for 2 million cycles.
f. Autoclave: No delamination when exposed to 2-psi (13.8-kPa) pressure at a temperature of 212 deg F (100 deg C) for 2-1/2 hours.
g. Fire-Test-Response Characteristics: Class A according to ASTM E 108.

2. Insulation Core: Modified isocyanurate or polyurethane foam using a non-CFC blowing agent, with maximum flame-spread and smoke-developed indexes of 25 and 450, respectively.

a. Closed-Cell Content: 90 percent when tested according to ASTM D 6226.
b. Density: 2.0 to 2.6 lb/cu. ft. (32 to 42 kg/cu. m) when tested according to ASTM D 1622.
c. Compressive Strength: Minimum 20 psi (140 kPa) when tested according to ASTM D 1621.
d. Shear Strength: 26 psi (179 kPa) when tested according to ASTM C 273.

B. Standing-Seam-Profile, Foamed-Insulation-Core Metal Roof Panels: Formed with vertical tongue-and-groove ribs at panel edges and between ribs; designed for sequential installation by interlocking tongue-and-groove panel edges and mechanically attaching panels to supports using concealed clips located between panels and engaging edges of adjacent panels, and mechanically seaming panels together.

1. Metallic-Coated Steel Sheet: Facings of zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M,

Class AZ50 (Class AZM150) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

a. Nominal Thickness: 0.022 inch (0.56 mm).
b. Exterior Finish: Three-coat fluoropolymer.

1) Color: Match Architect's samples.

c. Interior Finish: Three-coat fluoropolymer.

1) Color: Match Architect's samples.

2. Joint Type: Single folded.
3. Panel Coverage: 36 inches (914 mm).
4. Panel Thickness: 5.0 inches (127 mm).
5. Thermal-Resistance Value (R-Value): 31 according to ASTM C 1363.

2.3 MISCELLANEOUS MATERIALS

A. Miscellaneous Metal Subframing and Furring: ASTM C 645, cold-formed, metallic-coated steel sheet, ASTM A 653/A 653M, G90 (Z275 hot-dip galvanized) coating designation or ASTM A 792/A 792M, Class AZ50 (Class AZM150) coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.

B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.

1. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal panels.
2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

C. Flashing and Trim: Provide flashing and trim formed from same material as exterior facings of metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.

D. Gutters: Formed from same material, finish, and color as exterior facings of panels, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch- (2400-mm-) long sections, of size and metal thickness according

to SMACNA's "Architectural Sheet Metal Manual." Furnish gutter supports spaced a maximum of 36 inches (914 mm) o.c., fabricated from same metal as gutters. Provide wire ball strainers of compatible metal at outlets. Finish gutters to match metal roof panels.

E. Downspouts: Formed from same material, finish, and color as exterior facings of roof panels. Fabricate in 10-foot- (3-m-) long sections, complete with formed elbows and offsets, of size and metal thickness according to SMACNA's "Architectural Sheet Metal Manual." Finish downspouts to match gutters.

F. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.

G. Panel Sealants: Provide sealant types recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.

1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
2. Joint Sealant: ASTM C 920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended in writing by metal panel manufacturer.
3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.4 FABRICATION

A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
4. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
5. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.

    a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal panel manufacturer for application but not less than thickness of metal being secured.

2.5 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Exterior Facings and Accessories:

1. Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

D. Interior Facings:

1. Metallic Fluoropolymer: AAMA 621. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.

1. Examine primary and secondary roof framing to verify that rafters, purlins, angles, channels, and other structural panel support members and anchorages have been installed within alignment tolerances required by metal roof panel manufacturer.

B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.3 METAL PANEL INSTALLATION

A. General: Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Apply continuous ribbon of sealant to panel joint on concealed side of insulated metal roof panels as vapor seal; apply sealant to panel joint on exposed side of panels for weather seal.
2. Shim or otherwise plumb substrates receiving metal panels.
3. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.
4. Install screw fasteners in predrilled holes.
5. Locate and space fastenings in uniform vertical and horizontal alignment.
6. Install flashing and trim as metal panel work proceeds.
7. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.

8. Align bottoms of metal panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
9. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized-steel fasteners for surfaces exposed to the interior.

C. Anchor Clips: Anchor metal roof panels and other components of the Work securely in place, using manufacturer's approved fasteners according to manufacturers' written instructions.

D. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.

E. Standing-Seam, Foamed-Insulation-Core Metal Roof Panels: Fasten insulated metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended in writing by manufacturer.

1. Install clips to supports with self-tapping fasteners.
2. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so cleat, insulated metal roof panel, and factory-applied side-lap sealant are completely engaged.

F. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal panel system including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal roof panel manufacturers; or, if not indicated, provide types recommended in writing by metal roof panel manufacturer.

G. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without buckling and tool marks, and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and achieve waterproof performance.
2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (610 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently waterproof, form

expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).

H. Gutters: Join sections with riveted and soldered or lapped and sealed joints. Attach gutters to eave with gutter hangers spaced not more than 36 inches (914 mm) o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.

I. Downspouts: Join sections with telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch (25 mm) away from walls; locate fasteners at top and bottom and at approximately 60 inches (1500 mm) o.c. in between.

3.4 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align metal panel units within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect completed metal panel installation, including accessories. Report results in writing.

B. Remove and replace applications where tests and inspections indicate that they do not comply with specified requirements.

C. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.

D. Prepare test and inspection reports.

3.6 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 074113.23

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SECTION 074213.16 - METAL PLATE WALL PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes metal plate screen wall panels.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Owner's insurer if applicable, metal panel Installer, metal panel manufacturer's representative, structural-support Installer, and installers whose work interfaces with or affects metal panels, including installers of doors, windows, and louvers.
2. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
3. Review methods and procedures related to metal panel installation, including manufacturer's written instructions.
4. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.
5. Review flashings, special siding details, wall penetrations, openings, and condition of other construction that affect metal panels.
6. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
7. Review temporary protection requirements for metal panel assembly during and after installation.
8. Review procedures for repair of metal panels damaged after installation.
9. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

B. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment assembly, trim, flashings, closures, and accessories; and special details.
2. Accessories: Include details of the flashing, trim, and anchorage, at a scale of not less than 1-1/2 inches per 12 inches (1:10).
3. Submittal to include 3D modeling and renderings.
4. Delegated Design Submittal for Metal Plate Wall Panels indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the Qualified professional Engineer responsible for their preparation.

C. Samples for Initial Selection: For each type of metal panel indicated with factory-applied color finishes.

1. Include similar Samples of trim and accessories involving color selection.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each product, tests performed by a qualified testing agency.

C. Field quality-control reports.

D. Sample Warranties: For special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panels to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Manufacturer Qualifications:

1. Manufacturer to have ISO 9001: 2008 certifications supporting design and engineering work, as well as quality assurance.
2. Manufacturer to have welding coupon.
3. Manufacturer is required to demonstrate relevant experience with projects of similar scope and intent.

4. Manufacturer to have been in business no less than 10 years.
5. Manufacturer to provide proof that they have manufactured a minimum of 3 similar projects or products recently.

C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockup of typical metal panel assembly as shown on Drawings, including supports, attachments, and accessories.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal panels during installation.

1.9 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.10 COORDINATION

A. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including rupturing, cracking, or puncturing.
b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 330:

1. Wind Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.
3. Deflection Limits: For wind loads, no greater than 1/180 of the span.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 METAL PLATE SCREEN WALL PANELS

A. Metal Plate Wall Panels: Provide factory-formed, metal plate wall panels fabricated from single sheets of metal formed into profile for installation method indicated. Include attachment assembly components, panel stiffeners, and accessories required for weathertight system.

A. Basis-of-Design Product: Hendrick Architectural, Pattern 1, 50 RND on 1.75 stagger centers, 66.6% open area.

B. Panel Depth: 2 inches.

C. Aluminum Sheet: Tension leveled, smooth aluminum sheet, ASTM B 209 (ASTM B 209M), 0.125 inch (3.18 mm).

1. Exterior Finish: Three-coat fluoropolymer.

a. Color: Match Architect’s samples.

D. Attachment Assembly: Manufacturer’s standard.

2.3 MISCELLANEOUS MATERIALS

A. Miscellaneous Metal Furring: ASTM C 645, cold-formed, metallic-coated steel sheet, ASTM A 653/A 653M, G90 (Z275 hot-dip galvanized) coating designation or ASTM A 792/A 792M, Class AZ50 (Class AZM150) aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.

B. Miscellaneous Metal Subframing: G90 hot-dip galvanized structural steel members as detailed and as required to comply with performance requirements.

C. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.

D. Trim: Provide trim formed from aluminum as required to provide finished appearance. Finish trim with same finish system as adjacent metal panels.

E. Panel Fasteners: Self-tapping concealed screws designed to withstand design loads. Provide EPDM or PVC sealing washers for fasteners exposed to weather.

F. Panel Sealants: Refer to Section 079200 “Joint Sealants”.

2.4 FABRICATION

A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

C. Sheet Metal Trim: Fabricate trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
4. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
5. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.

    a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal wall panel manufacturer for application but not less than thickness of metal being secured.

2.5 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Aluminum Panels and Accessories:

1. Three-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.

1. Examine wall framing to verify that girts, angles, channels, studs, and other structural panel support members and anchorage have been installed within alignment tolerances required by metal wall panel manufacturer.
2. Examine wall sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal wall panel manufacturer.

B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.3 INSTALLATION

A. General: Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Shim or otherwise plumb substrates receiving metal panels.
2. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.
3. Install screw fasteners in predrilled holes.
4. Locate and space fastenings in uniform vertical and horizontal alignment.

5. Install flashing and trim as metal panel work proceeds.
6. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
7. Align bottoms of metal panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
8. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners:

1. Aluminum Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior.

C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.

D. Attachment Assembly, General: Install attachment assembly required to support metal plate wall panels and to provide a complete wall system, including subgirts, perimeter extrusions, tracks, drainage channels, panel clips, and anchor channels.

1. Include attachment to supports, panel-to-panel joinery, panel-to-dissimilar-material joinery, and panel-system joint seals.

E. Installation: Attach metal plate wall panels to supports at locations, spacings, and with fasteners recommended by manufacturer to achieve performance requirements specified.

1. Rainscreen Systems: Do not apply sealants to joints unless otherwise indicated.

F. Accessory Installation: Install accessories with positive anchorage to building and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal panel system including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal panel manufacturer; or, if not indicated, provide types recommended in writing by metal panel manufacturer.

G. Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that are permanently watertight.

1. Install exposed trim that is without buckling and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof performance.

2. Expansion Provisions: Provide for thermal expansion of exposed trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (605 mm) of corner or intersection.

3.4 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align metal plate wall panel units within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m), non-accumulative, on level, plumb, and location lines as indicated, and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect completed metal wall panel installation, including accessories.

B. Remove and replace metal wall panels where tests and inspections indicate that they do not comply with specified requirements.

C. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.

D. Prepare test and inspection reports.

3.6 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. After metal panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

C. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 074213.16

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SECTION 074213.19 - INSULATED METAL WALL PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Foamed-insulation-core metal wall panels.

B. Related Requirements:

1. Section 074113.23 “Insulated Metal Roof Panels”.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Owner's insurer if applicable, metal panel Installer, metal panel manufacturer's representative, structural-support Installer, and installers whose work interfaces with or affects metal panels, including installers of doors, windows, and louvers.
2. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
3. Review methods and procedures related to metal panel installation, including manufacturer's written instructions.
4. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.
5. Review flashings, special siding details, wall penetrations, openings, and condition of other construction that affect metal panels.
6. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
7. Review temporary protection requirements for metal panel assembly during and after installation.
8. Review procedures for repair of metal panels damaged after installation.
9. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
2. Accessories: Include details of the flashing, trim, and anchorage systems, at a scale of not less than 1-1/2 inches per 12 inches (1:10).

D. Samples for Initial Selection: For each type of metal panel indicated with factory-applied color finishes.

E. Samples for Verification: For each type of exposed finish, prepared on Samples of size indicated below.

1. Metal Panels: 12 inches (305 mm) long by actual panel width. Include fasteners, closures, and other metal panel accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each product, tests performed by a qualified testing agency.

C. Field quality-control reports.

D. Sample Warranties: For special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panels to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal panels during installation.

1.9 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.10 COORDINATION

A. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including rupturing, cracking, or puncturing.
b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 72:

1. Wind Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.
3. Deflection Limits: For wind loads, no greater than 1/180 of the span.

C. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) when tested according to ASTM E 283 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa).

D. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft. (300 Pa).

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

F. Fire-Test-Response Characteristics: Provide metal wall panels and system components with the following fire-test-response characteristics, as determined by testing identical panels and system components per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify products with appropriate markings of applicable testing agency.

1. Intermediate-Scale Multistory Fire Test: Tested mockup, representative of completed multistory wall assembly of which wall panel is a part, complies with NFPA 285 for test method and required fire-test-response characteristics of exterior non-load-bearing wall panel assemblies.
2. Radiant Heat Exposure: No ignition when tested according to NFPA 268.
3. Potential Heat: Acceptable level when tested according to NFPA 259.
4. Surface-Burning Characteristics: Provide wall panels with a flame-spread index of 25 or less and a smoke-developed index of 450 or less, per ASTM E 84.

2.2 FOAMED-INSULATION-CORE METAL WALL PANELS

A. General: Provide factory-formed and -assembled metal wall panels fabricated from two metal facing sheets and insulation core foamed in place during fabrication, and with joints between panels designed to form weathertight seals. Include accessories required for weathertight installation.

1. Insulation Core: Modified isocyanurate or polyurethane foam using a non-CFC blowing agent, with maximum flame-spread and smoke-developed indexes of 25 and 450, respectively.

    a. Closed-Cell Content: 90 percent when tested according to ASTM D 6226.
    b. Density: 2.0 to 2.6 lb/cu. ft. (32 to 42 kg/cu. m) when tested according to ASTM D 1622.
    c. Compressive Strength: Minimum 20 psi (140 kPa) when tested according to ASTM D 1621.
    d. Shear Strength: 26 psi (179 kPa) when tested according to ASTM C 273/C 273M.

B. Concealed-Fastener, Foamed-Insulation-Core Metal Wall Panels: Formed with tongue-and-groove panel edges; designed for sequential installation by interlocking panel edges and mechanically attaching panels to supports using concealed clips or fasteners.

1. Metallic-Coated Steel Sheet: Facings of zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M, Class AZ50 (Class AZM150) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

    a. Nominal Thickness: 0.022 inch (0.56 mm).
    b. Exterior Finish: Three-coat fluoropolymer.

1) Color: Match Architect's samples.

c. Interior Finish: Three-coat fluoropolymer.

1) Color: Match Architect's samples.

2. Panel Coverage: 36 inches (914 mm) nominal.
3. Panel Thickness: 3.0 inches (76 mm).
4. Thermal-Resistance Value (R-Value): 18 according to ASTM C 1363.

2.3 MISCELLANEOUS MATERIALS

A. Miscellaneous Metal Subframing and Furring: ASTM C 645, cold-formed, metallic-coated steel sheet, ASTM A 653/A 653M, G90 (Z275 hot-dip galvanized) coating designation or ASTM A 792/A 792M, Class AZ50 (Class AZM150) aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.

B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.

1. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal panels.
2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.

D. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.

E. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.

1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic,

nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.

2. Joint Sealant: ASTM C 920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended in writing by metal panel manufacturer.
3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.4 FABRICATION

A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
2. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
3. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
4. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
5. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.

    a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal wall panel manufacturer for application but not less than thickness of metal being secured.

2.5 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Steel Panels and Accessories:

1. Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.

1. Examine wall framing to verify that girts, angles, channels, studs, and other structural panel support members and anchorage have been installed within alignment tolerances required by metal wall panel manufacturer.
2. Examine wall sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal wall panel manufacturer.

B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.3 METAL PANEL INSTALLATION

A. General: Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Shim or otherwise plumb substrates receiving metal panels.
2. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.
3. Install screw fasteners in predrilled holes.
4. Locate and space fastenings in uniform vertical and horizontal alignment.
5. Install flashing and trim as metal panel work proceeds.
6. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
7. Align bottoms of metal panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
8. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners:

1. Steel Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized-steel fasteners for surfaces exposed to the interior.

C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.

D. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weathertight performance of metal wall panel assemblies. Provide types of gaskets, fillers, and sealants indicated by metal panel manufacturer; or, if not indicated, provide types recommended by metal wall panel manufacturer.

1. Seal metal wall panel end laps with double beads of tape or sealant, full width of panel. Seal side joints where recommended by metal wall panel manufacturer.
2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."

3.4 INSULATED METAL WALL PANEL INSTALLATION

A. General: Apply continuous ribbon of sealant to panel joint on concealed side of insulated metal wall panels as vapor seal; apply sealant to panel joint on exposed side of panels for weather seal.

1. Fasten foamed-insulation-core metal wall panels to supports with fasteners at each lapped joint at location and spacing and with fasteners recommended by manufacturer.
2. Apply panels and associated items true to line for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
3. Provide metal-backed washers under heads of exposed fasteners on weather side of insulated metal wall panels.
4. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
5. Provide sealant tape at lapped joints of insulated metal wall panels and between panels and protruding equipment, vents, and accessories.
6. Apply a continuous ribbon of sealant tape to panel side laps and elsewhere as needed to make panels weathertight.

B. Foamed-Insulation-Core Metal Wall Panels: Fasten metal wall panels to supports with concealed clips at each joint at location and spacing and with fasteners recommended by manufacturer. Fully engage tongue and groove of adjacent panels.

1. Install clips to supports with self-tapping fasteners.

C. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal panel system including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal panel manufacturer; or, if not indicated, provide types recommended by metal panel manufacturer.

D. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that are permanently watertight.

1. Install exposed flashing and trim that is without buckling and tool marks, and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to achieve waterproof performance.
2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (610 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect completed metal wall panel installation, including accessories.

B. Metal wall panels will be considered defective if they do not pass test and inspections.

C. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.

D. Prepare test and inspection reports.

3.6 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. After metal panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

C. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 074213.19

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SECTION 075423 - THERMOPLASTIC POLYOLEFIN (TPO) ROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Adhered thermoplastic polyolefin (TPO) roofing system.
2. Vapor retarder.
3. Roof insulation.

B. Related Requirements:

1. Section 061000 "Rough Carpentry" for wood nailers, curbs, and blocking; and for wood-based, structural-use roof deck panels.
2. Section 076200 "Sheet Metal Flashing and Trim" for metal roof flashings and counterflashings.

1.3 DEFINITIONS

A. Roofing Terminology: Definitions in ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" apply to work of this Section.

1.4 PREINSTALLATION MEETINGS

A. Preliminary Roofing Conference: Before starting roof deck construction, conduct conference at Project site.

1. Meet with Owner, Architect, Building Envelope Commissioning Agent, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.

3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review deck substrate requirements for conditions and finishes, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

B. Preinstallation Roofing Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Building Envelope Commissioning Agent, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Sustainable Sites Credit Heat Island Reduction: Meet requirements for Option 1, Option 2, or both.
2. Product Data for Materials and Resources Building Product Disclosure and Optimization-Environmental Product Declarations: Meet requirements for Option 1 or Option 2.

3. Product Data for Materials and Resources Building Product Disclosure and Optimization-Sourcing of Raw Material: Meet requirements for Option 1 or Option 2.
4. Product Data for Materials and Resources Building Product Disclosure and Optimization-Material Ingredients: Meet requirements for Option 1 and/or Option 2 and/or Option 3.
5. Product Data for Indoor Environmental Quality Low-Emitting Materials: Meet requirement for Option 1 or Option 2.

C. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work, including:

1. Base flashings and membrane terminations.
2. Tapered insulation, including slopes.
3. Roof plan showing orientation of steel roof deck and orientation of roofing, fastening spacings, and patterns for mechanically fastened roofing.
4. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.

1. Submit evidence of compliance with performance requirements.

C. Product Test Reports: For components of roofing system, tests performed by manufacturer and witnessed by a qualified testing agency.

D. Research/Evaluation Reports: For components of roofing system, from ICC-ES.

E. Field quality-control reports.

F. Sample Warranties: For manufacturer's special warranties.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing system to include in maintenance manuals.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer that is FM Global approved for roofing system identical to that used for this Project.

B. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.

1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.

D. Handle and store roofing materials, and place equipment in a manner to avoid permanent deflection of deck.

1.10 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Special warranty includes roofing, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, roof pavers, and other components of roofing system.
2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain components including roof insulation and fasteners for roofing system from same manufacturer as membrane roofing.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Installed roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roofing and base flashings shall remain watertight.

1. Accelerated Weathering: Roofing system shall withstand 2000 hours of exposure when tested according to ASTM G 152, ASTM G 154, or ASTM G 155.
2. Impact Resistance: Roofing system shall resist impact damage when tested according to ASTM D 3746 or ASTM D 4272.

B. Material Compatibility: Roofing materials shall be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roofing manufacturer based on testing and field experience.

C. FM Global Listing: Roofing, base flashings, and component materials shall comply with requirements in FM Global 4450 or FM Global 4470 as part of a built-up roofing system, and shall be listed in FM Global's "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.

1. Fire/Windstorm Classification: Class 1A-60.
2. Hail-Resistance Rating: MH.

D. Solar Reflectance Index: Not less than 78 when calculated according to ASTM E 1980, based on testing identical products by a qualified testing agency.

E. Energy Star Listing: Roofing system shall be listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.

F. Exterior Fire-Test Exposure: ASTM E 108 or UL 790, Class A; for application and roof slopes indicated; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

2.3 TPO ROOFING

A. Fabric-Reinforced TPO Sheet: ASTM D 6878, internally fabric- or scrim-reinforced, uniform, flexible fabric-backed TPO sheet.

1. Thickness: 60 mils (1.5 mm), nominal.
2. Exposed Face Color: White.

2.4 AUXILIARY ROOFING MATERIALS

A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing.

1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
2. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content:

a. Plastic Foam Adhesives: 50 g/L.
b. Gypsum Board and Panel Adhesives: 50 g/L.
c. Multipurpose Construction Adhesives: 70 g/L.
d. Fiberglass Adhesives: 80 g/L.
e. Single-Ply Roof Membrane Adhesives: 250 g/L.
f. Single-Ply Roof Membrane Sealants: 450 g/L.
g. Nonmembrane Roof Sealants: 300 g/L.
h. Sealant Primers for Nonporous Substrates: 250 g/L.
i. Sealant Primers for Porous Substrates: 775 g/L.
j. Other Adhesives and Sealants: 250 g/L.

B. Sheet Flashing: Manufacturer's standard unreinforced TPO sheet flashing, 55 mils (1.4 mm) thick, minimum, of same color as TPO sheet.

C. Bonding Adhesive: Manufacturer's standard.

D. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.

E. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch thick (25 mm wide by 1.3 mm thick), prepunched.

F. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening roofing to substrate, and acceptable to roofing system manufacturer.

G. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.

2.5 SUBSTRATE BOARDS

A. Substrate Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, Type X, 5/8 inch (16 mm) thick.

B. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening substrate board to roof deck.

2.6 VAPOR RETARDER

A. Self-Adhering-Sheet Vapor Retarder: ASTM D 1970, polyethylene film laminated to layer of rubberized asphalt adhesive, minimum 40-mil- (1.0-mm-) total thickness; maximum permeance rating of 0.1 perm (6 ng/Pa x s x sq. m); cold applied, with slip-resisting surface and release paper backing. Provide primer when recommended by vapor-retarder manufacturer.

2.7 ROOF INSULATION

A. General: Preformed roof insulation boards manufactured or approved by TPO roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated and that produce FM Global-approved roof insulation.

B. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2, felt or glass-fiber mat facer on both major surfaces.

C. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.

D. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

2.8 INSULATION ACCESSORIES

A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with roofing.

B. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening roof insulation and cover boards to substrate, and acceptable to roofing system manufacturer.

C. Insulation Adhesive: Insulation manufacturer's recommended adhesive formulated to attach roof insulation to substrate or to another insulation layer as follows:

1. Full-spread spray-applied, low-rise, two-component urethane adhesive.

D. Cover Board: ASTM C 1177/C 1177M, glass-mat, water-resistant gypsum substrate, 5/8 inch (16 mm) thick.

2.9 ASPHALT MATERIALS

A. Roofing Asphalt: ASTM D 312, Type III or Type IV.

2.10 WALKWAYS

A. Flexible Walkways: Factory-formed, nonporous, heavy-duty, slip-resisting, surface-textured walkway pads or rolls, approximately 3/16 inch (5 mm) thick and acceptable to roofing system manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work:

1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
3. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Section 053100 "Steel Decking."

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.

B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.

3.3 ROOFING INSTALLATION, GENERAL

A. Install roofing system according to roofing system manufacturer's written instructions.

B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.

3.4 SUBSTRATE BOARD INSTALLATION

A. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.

1. Fasten substrate board to top flanges of steel deck according to recommendations in FM Global's "RoofNav" and FM Global Loss Prevention Data Sheet 1-29 for specified Windstorm Resistance Classification.

3.5 VAPOR-RETARDER INSTALLATION

A. Self-Adhering-Sheet Vapor Retarder: Prime substrate if required by manufacturer. Install self-adhering-sheet vapor retarder over area to receive vapor retarder, side and end lapping each sheet a minimum of 3-1/2 inches (90 mm) and 6 inches (150 mm), respectively. Seal laps by rolling.

B. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into roofing system.

3.6 INSULATION INSTALLATION

A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.

B. Comply with roofing system and insulation manufacturer's written instructions for installing roof insulation.

C. Install tapered insulation under area of roofing to conform to slopes indicated.

D. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.

E. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.

F. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch (6 mm) with insulation.

1. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.

G. Mechanically Fastened and Adhered Insulation: Install each layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.

1. Fasten first layer of insulation according to requirements in FM Global's "RoofNav" for specified Windstorm Resistance Classification.
2. Set each subsequent layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

H. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together.

1. Fasten cover boards according to requirements in FM Global's "RoofNav" for specified Windstorm Resistance Classification.

3.7 ADHERED ROOFING INSTALLATION

A. Adhere roofing over area to receive roofing according to roofing system manufacturer's written instructions. Unroll roofing and allow to relax before retaining.

B. Start installation of roofing in presence of roofing system manufacturer's technical personnel.

C. Accurately align roofing, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

D. Bonding Adhesive: Apply to substrate and underside of roofing at rate required by manufacturer, and allow to partially dry before installing roofing. Do not apply to splice area of roofing.

E. In addition to adhering, mechanically fasten roofing securely at terminations, penetrations, and perimeter of roofing.

F. Apply roofing with side laps shingled with slope of roof deck where possible.

G. Seams: Clean seam areas, overlap roofing, and hot-air weld side and end laps of roofing and sheet flashings according to manufacturer's written instructions, to ensure a watertight seam installation.

1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet.
2. Verify field strength of seams a minimum of twice daily, and repair seam sample areas.

3. Repair tears, voids, and lapped seams in roofing that do not comply with requirements.

H. Spread sealant bed over deck-drain flange at roof drains, and securely seal roofing in place with clamping ring.

3.8 BASE FLASHING INSTALLATION

A. Install sheet flashings and preformed flashing accessories, and adhere to substrates according to roofing system manufacturer's written instructions.

B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate, and allow to partially dry. Do not apply to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

D. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Hot-air weld side and end laps to ensure a watertight seam installation.

E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.9 WALKWAY INSTALLATION

A. Flexible Walkways: Install walkway products in locations indicated. Heat weld to substrate or adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to inspect substrate conditions, surface preparation, membrane application, flashings, protection, and drainage components, and to furnish reports to Architect.

B. Flood Testing: Flood test each roofing area for leaks, according to recommendations in ASTM D 5957, after completing roofing and flashing but before overlying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.

1. Flood to an average depth of 2-1/2 inches (65 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm). Maintain 2 inches (50 mm) of clearance from top of base flashing.
2. Flood each area for 48 hours.
3. After flood testing, repair leaks, repeat flood tests, and make further repairs until roofing and flashing installations are watertight.

C. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.

D. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.

E. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

3.11 PROTECTING AND CLEANING

A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 075423

SECTION 077100 - ROOF SPECIALTIES

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on Masterworks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on Masterworks/Supporting Information.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copings.
2. Reglets and counterflashings.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for downspout guards and downspout boots.
2. [**Section 061000 "Rough Carpentry"**] [**Section 061053 "Miscellaneous Rough Carpentry"**] for wood nailers, curbs, and blocking.
3. Section 074113.16 "Standing-Seam Metal Roof Panels" for roof-edge drainage-system components provided by metal-roof-panel manufacturer.
4. Section 076200 "Sheet Metal Flashing and Trim" for custom- and site-fabricated sheet metal flashing and trim.
5. Section 077200 "Roof Accessories" for set-on-type curbs, equipment supports, roof hatches, vents, and other manufactured roof accessory units.
6. Section 077253 "Snow Guards" for manufactured snow guard devices.
7. Section 079200 "Joint Sealants" for field-applied sealants between roof specialties and adjacent materials.
8. Section 079500 "Expansion Control" for manufactured sheet metal expansion-joint covers.

C. Preinstallation Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Owner's insurer if applicable, roofing-system testing and inspecting agency representative, roofing Installer, roofing-system manufacturer's representative, Installer, structural-support Installer, and installers whose work interfaces with or affects roof specialties, including installers of roofing materials and accessories.
2. Examine substrate conditions for compliance with requirements, including flatness and attachment to structural members.
3. Review special roof details, roof drainage, and condition of other construction that will affect roof specialties.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Shop Drawings: For roof specialties.

1. Include plans, elevations, expansion-joint locations, keyed details, and attachments to other work. Distinguish between plant- and field-assembled work.
2. Include details for expansion and contraction; locations of expansion joints, including direction of expansion and contraction.
3. Indicate profile and pattern of seams and layout of fasteners, cleats, clips, and other attachments.
4. Detail termination points and assemblies, including fixed points.
5. Include details of special conditions.

D. Samples: For each type of roof specialty and for each color and texture specified.

E. Samples for Initial Selection: For each type of roof specialty indicated with factory-applied color finishes.

F. Samples for Verification:

1. Include Samples of each type of roof specialty to verify finish and color selection, in manufacturer's standard sizes.
2. Include [**copings**] [**roof-edge specialties**] [**roof-edge drainage systems**] [**reglets and counterflashings**] made from 12-inch (300-mm) lengths of full-size components in specified material, and including fasteners, cover joints, accessories, and attachments.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Product Certificates: For each type of roof specialty.

C. Product Test Reports: For copings, for tests performed by a qualified testing agency.

D. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer offering products meeting requirements that are [**FM Approvals listed for specified class**] [**and**] [**SPRI ES-1 tested to specified design pressure**].

B. Source Limitations: Obtain roof specialties approved by manufacturer providing roofing-system warranty specified in Section <**Insert Section number and title**>.

C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and set quality standards for fabrication and installation.

1. Build mockup of typical roof edge as shown on Drawings.
2. Build mockup of typical roof edge as part of Integrated Exterior Mockup specified in Section 014000 "Quality Requirements"
3. Build mockup of typical roof edge, including [**fascia**] [**gutter**] [**and**] [**downspout**] <**Insert item**>, approximately [**10 feet (3.0 m)**] <**Insert dimension**> long, including supporting construction, seams, attachments,[**underlayment,**] and accessories.
4. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store roof specialties in contact with other materials that might cause staining, denting, or other surface damage. Store roof specialties away from uncured concrete and masonry.

B. Protect strippable protective covering on roof specialties from exposure to sunlight and high humidity, except to extent necessary for the period of roof-specialty installation.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify profiles and tolerances of roof-specialty substrates by field measurements before fabrication, and indicate measurements on Shop Drawings.

B. Coordination: Coordinate roof specialties with flashing, trim, and construction of parapets, roof deck, roof and wall panels, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.9 WARRANTY

A. Roofing-System Warranty: Roof specialties are included in warranty provisions in Section <**Insert Section number**> "<**Insert roof Section title**>".

B. Special Warranty on Painted Finishes: Manufacturer agrees to repair finish or replace roof specialties that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: [**20**] [**10**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Roof specialties shall withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [**25**] <**Insert number**> percent.

C. FM Approvals' Listing: Manufacture and install [**copings**] [**roof-edge specialties**] that are listed in FM Approvals' "RoofNav" and approved for windstorm classification, [**Class 1-60**] [**Class 1-75**] [**Class 1-90**] [**Class 1-105**] [**Class 1-120**] <**Insert class**>. Identify materials with FM Approvals' markings.

D. SPRI Wind Design Standard: Manufacture and install [**copings**] [**roof-edge specialties**] tested according to SPRI ES-1 and capable of resisting the following design pressures:

1. Design Pressure: [**As indicated on Drawings**] <**Insert design pressure**>.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Provide clips that resist rotation and avoid shear stress as a result of thermal movements. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): [**120 deg F (67 deg C), ambient; 180 deg F (100 deg C)**] <**Insert temperature range**>, material surfaces.

2.2 COPINGS

1. Formed Aluminum Sheet Coping Caps: Aluminum sheet, [**0.040 inch (1.02 mm) thick**] [**0.050 inch (1.27 mm) thick**] [**0.063 inch (1.60 mm) thick**] [**thickness as required to meet performance requirements**] <**Insert thickness**>.

   a. Surface: [**Smooth, flat**] [**Embossed**] finish.
   b. Finish: [**Mill**] [**Two-coat fluoropolymer**] [**Three-coat fluoropolymer**] [**Two-coat mica fluoropolymer**] [**Three-coat metallic fluoropolymer**] [**Clear anodic**] [**Color anodic**] <**Insert finish**>.
   c. Color: [**Light bronze**] [**Medium bronze**] [**Dark bronze**] [**Black**] [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.

2. Extruded-Aluminum Coping Caps: Extruded aluminum, [**0.080 inch (2.03 mm) thick**] [**0.125 inch (3.18 mm) thick**] [**thickness as required to meet performance requirements**] <**Insert thickness**>.

   a. Finish: [**Mill**] [**Two-coat fluoropolymer**] [**Three-coat fluoropolymer**] [**Two-coat mica fluoropolymer**] [**Three-coat metallic fluoropolymer**] [**Clear anodic**] [**Color anodic**] <**Insert finish**>.
   b. Color: [**Light bronze**] [**Medium bronze**] [**Dark bronze**] [**Black**] [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.

3. Corners: Factory mitered and continuously welded.
4. Special Fabrications: [**Radiussed sections**] [**Arched sections**] [**Bullnose-face leg**] [**Two-way sloped coping cap**] <**Insert description**>.
5. Coping-Cap Attachment Method: [**Snap-on**] [**or**] [**face leg hooked to continuous cleat with back leg fastener exposed**], fabricated from coping-cap material.

    a. Snap-on Coping Anchor Plates: Concealed, galvanized-steel sheet, 12 inches (300 mm) wide, with integral cleats.
    b. Face-Leg Cleats: Concealed, continuous galvanized-steel sheet.

2.3 REGLETS AND COUNTERFLASHINGS

A. Reglets: Manufactured units formed to provide secure interlocking of separate reglet and counterflashing pieces, from the following exposed metal:

1. Formed Aluminum: 0.024 inch (0.61 mm) thick.
2. Corners: Factory mitered and continuously welded.
3. Surface-Mounted Type: Provide reglets with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.
4. Concrete Type, Embedded: Provide temporary closure tape to keep reglet free of concrete materials, special fasteners for attaching reglet to concrete forms, and guides to ensure alignment of reglet section ends.
5. Masonry Type, Embedded: Provide reglets with offset top flange for embedment in masonry mortar joint.
6. Multiuse Type, Embedded: For multiuse embedment in cast-in-place concrete and masonry mortar joints.

B. Counterflashings: Manufactured units of heights to overlap top edges of base flashings by 4 inches (100 mm) and in lengths not exceeding 12 feet (3.6 m) designed to snap into [**reglets**] [**or**] [**through-wall-flashing receiver**] and compress against base flashings with joints lapped, from the following exposed metal:

1. Formed Aluminum: 0.024 inch (0.61 mm) thick.

C. Accessories:

1. Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where reglet is provided separate from metal counterflashing.
2. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing lower edge.

D. Aluminum Finish: Clear anodic.

1. Color: As selected by Architect from manufacturer's full range.

2.4 MATERIALS

A. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required, with temper to suit forming operations and performance required.

B. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper recommended by manufacturer for type of use and finish indicated, finished as follows:

2.5 UNDERLAYMENT MATERIALS

A. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils (0.76 to 1.0 mm) thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.

1. Thermal Stability: ASTM D 1970/D 1970M; stable after testing at 240 deg F (116 deg C).
2. Low-Temperature Flexibility: ASTM D 1970/D 1970M; passes after testing at minus 20 deg F (29 deg C).

B. Felt: ASTM D 226/D 226M, Type II (No. 30), asphalt-saturated organic felt, nonperforated.

C. Slip Sheet: Rosin-sized building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum.

2.6 MISCELLANEOUS MATERIALS

A. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to meet performance requirements. Furnish the following unless otherwise indicated:

1. Exposed Penetrating Fasteners: Gasketed screws with hex washer heads matching color of sheet metal.
2. Fasteners for Aluminum: Aluminum or Series 300 stainless steel.
3. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.
4. Fasteners for Zinc-Coated (Galvanized) Steel Sheet: Series 300 stainless steel or hot-dip zinc-coated steel according to ASTM A 153/A 153M or ASTM F 2329.

B. Elastomeric Sealant: ASTM C 920, elastomeric [**polyurethane**] [**silicone**] polymer sealant of type, grade, class, and use classifications required by roofing-specialty manufacturer for each application.

C. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type joints with limited movement.

D. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

2.7 FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

D. Coil-Coated Galvanized-Steel Sheet Finishes:

1. High-Performance Organic Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with ASTM A 755/A 755M and coating and resin manufacturers' written instructions.

    a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
    b. Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
    c. Two-Coat Mica Fluoropolymer: AAMA 621. Fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
    d. Three-Coat Metallic Fluoropolymer: AAMA 621. Fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
    e. Concealed Surface Finish: Apply pretreatment and manufacturer's standard acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

E. Coil-Coated Aluminum Sheet Finishes:

1. High-Performance Organic Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

a. Two-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
b. Three-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
c. Two-Coat Mica Fluoropolymer: AAMA 2605. Fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
d. Three-Coat Metallic Fluoropolymer: AAMA 2605. Fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
e. Concealed Surface Finish: Apply pretreatment and manufacturer's standard acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

2. Clear Anodic Finish: AAMA 611, [**AA-M12C22A41, Class I, 0.018 mm**] [**AA-M12C22A31, Class II, 0.010 mm**] or thicker.
3. Color Anodic Finish: AAMA 611, [**AA-M12C22A42/A44, Class I, 0.018 mm**] [**AA-M12C22A32/A34, Class II, 0.010 mm**] or thicker.

F. Aluminum Extrusion Finishes:

1. High-Performance Organic Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

a. Two-Coat Fluoropolymer: AAMA [**2604**] [**2605**]. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
b. Three-Coat Fluoropolymer: AAMA [**2604**] [**2605**]. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
c. Two-Coat Mica Fluoropolymer: AAMA [**2604**] [**2605**]. Fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
d. Three-Coat Metallic Fluoropolymer: AAMA [**2604**] [**2605**]. Fluoropolymer finish with suspended metallic flakes containing not less than 70 percent

PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

e. Concealed Surface Finish: Apply pretreatment and manufacturer's standard acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

2. Clear Anodic Finish: AAMA 611, [**AA-M12C22A41, Class I, 0.018 mm**] [**AA-M12C22A31, Class II, 0.010 mm**] or thicker.
3. Color Anodic Finish: AAMA 611, [**AA-M12C22A42/A44, Class I, 0.018 mm**] [**AA-M12C22A32/A34, Class II, 0.010 mm**] or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.

B. Examine walls, roof edges, and parapets for suitable conditions for roof specialties.

C. Verify that substrate is sound, dry, smooth, clean, sloped for drainage where applicable, and securely anchored.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 UNDERLAYMENT INSTALLATION

A. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches (152 mm) staggered 24 inches (610 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps with roller. Cover underlayment within 14 days.

1. Apply continuously under [**copings**] [**roof-edge specialties**] [**and**] [**reglets and counterflashings**].
2. Coordinate application of self-adhering sheet underlayment under roof specialties with requirements for continuity with adjacent air barrier materials.

B. Felt Underlayment: Install with adhesive for temporary anchorage to minimize use of mechanical fasteners under roof specialties. Apply in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).

C. Slip Sheet: Install with tape or adhesive for temporary anchorage to minimize use of mechanical fasteners under roof specialties. Apply in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).

3.3 INSTALLATION, GENERAL

A. General: Install roof specialties according to manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement. Use fasteners, solder, protective coatings, separators, underlayments, sealants, and other miscellaneous items as required to complete roof-specialty systems.

1. Install roof specialties level, plumb, true to line and elevation; with limited oil-canning and without warping, jogs in alignment, buckling, or tool marks.
2. Provide uniform, neat seams with minimum exposure of solder and sealant.
3. Install roof specialties to fit substrates and to result in weathertight performance. Verify shapes and dimensions of surfaces to be covered before manufacture.
4. Torch cutting of roof specialties is not permitted.
5. Do not use graphite pencils to mark metal surfaces.

B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.

1. Coat concealed side of [**uncoated aluminum**] [**and**] [**stainless-steel**] roof specialties with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
2. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof specialties for waterproof performance.

C. Expansion Provisions: Allow for thermal expansion of exposed roof specialties.

1. Space movement joints at a maximum of 12 feet (3.6 m) with no joints within 18 inches (450 mm) of corners or intersections unless otherwise indicated on Drawings.
2. When ambient temperature at time of installation is between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures.

D. Fastener Sizes: Use fasteners of sizes that penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.

E. Seal concealed joints with butyl sealant as required by roofing-specialty manufacturer.

F. Seal joints as required for weathertight construction. Place sealant to be completely concealed in joint. Do not install sealants at temperatures below 40 deg F (4 deg C).

G. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets to be soldered to a width of 1-1/2 inches (38 mm); however, reduce pre-tinning where pre-tinned surface would show in completed Work. Tin edges of uncoated copper sheets using solder for copper. Do not use torches for soldering. Heat surfaces to receive solder and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.

3.4 COPING INSTALLATION

A. Install cleats, anchor plates, and other anchoring and attachment accessories and devices with concealed fasteners.

B. Anchor copings with manufacturer's required devices, fasteners, and fastener spacing to meet performance requirements.

1. Interlock face and back leg drip edges of snap-on coping cap into cleated anchor plates anchored to substrate at manufacturer's required spacing that meets performance requirements.
2. Interlock face-leg drip edge into continuous cleat anchored to substrate at manufacturer's required spacing that meets performance requirements. Anchor back leg of coping with screw fasteners and elastomeric washers at manufacturer's required spacing that meets performance requirements.

3.5 ROOF-EDGE SPECIALITIES INSTALLATION

A. Install cleats, cants, and other anchoring and attachment accessories and devices with concealed fasteners.

B. Anchor roof edgings with manufacturer's required devices, fasteners, and fastener spacing to meet performance requirements.

3.6 REGLET AND COUNTERFLASHING INSTALLATION

A. General: Coordinate installation of reglets and counterflashings with installation of base flashings.

B. Embedded Reglets: See [**Section 033000 "Cast-in-Place Concrete"**] [**and**] [**Section 042000 "Unit Masonry"**] for installation of reglets.

C. Surface-Mounted Reglets: Install reglets to receive flashings where flashing without embedded reglets is indicated on Drawings. Install at height so that inserted counterflashings overlap 4 inches (100 mm) over top edge of base flashings.

D. Counterflashings: Insert counterflashings into reglets or other indicated receivers; ensure that counterflashings overlap 4 inches (100 mm) over top edge of base

flashings. Lap counterflashing joints a minimum of 4 inches (100 mm) and bed with butyl sealant. Fit counterflashings tightly to base flashings.

3.7 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder and sealants.

C. Remove temporary protective coverings and strippable films as roof specialties are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain roof specialties in a clean condition during construction.

D. Replace roof specialties that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION 077100

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SECTION 077200 - ROOF ACCESSORIES

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on Masterworks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on Masterworks/Supporting Information.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Roof curbs.
2. Equipment supports.
3. Hatch-type heat and smoke vents.
4. Dropout-type heat and smoke vents.
5. Gravity ventilators.
6. Pipe and duct supports.
7. Pipe portals.
8. Preformed flashing sleeves.
9. Roof walkways.

B. Related Sections:

1. Section 055000 "Metal Fabrications" for metal vertical ladders, ships' ladders, and stairs for access to roof hatches.
2. Section 076100 "Sheet Metal Roofing" for shop- and field-formed roof curbs and snow guards for sheet metal roofing.
3. Section 076200 "Sheet Metal Flashing and Trim" for shop- and field-formed metal flashing, roof-drainage systems, roof expansion-joint covers, and miscellaneous sheet metal trim and accessories.
4. Section 077100 "Roof Specialties" for manufactured fasciae, copings, gravel stops, gutters and downspouts, and counterflashing.
5. Section 077129 "Manufactured Roof Expansion Joints" for manufactured roof expansion-joint covers.

6. Section 230548 "Vibration and Seismic Controls for HVAC" for special curbs designed to accommodate seismic and vibration controls.
7. Section 233423 "HVAC Power Ventilators" for power roof-mounted ventilators.
8. Section 237413 "Packaged, Outdoor, Central-Station Air-Handling Units" for standard curbs specified with rooftop units.

1.3 COORDINATION

A. Coordinate layout and installation of roof accessories with [**roofing membrane and base flashing and**]interfacing and adjoining construction to provide a leakproof, weathertight, secure, and noncorrosive installation.

B. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of roof accessory.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For roof accessories.

1. Include plans, elevations, keyed details, and attachments to other work. Indicate dimensions, loadings, and special conditions. Distinguish between plant- and field-assembled work.

C. Samples: For each exposed product and for each color and texture specified, prepared on Samples of size to adequately show color.

D. Delegated-Design Submittal: For [**roof curbs**] [**equipment supports**] [**and**] [**walkways**] indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail mounting, securing, and flashing of roof-mounted items to roof structure. Indicate coordinating requirements with roof membrane system.
2. Wind-Restraint Details: Detail fabrication and attachment of wind restraints. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof plans, drawn to scale, and coordinating penetrations and roof-mounted items. Show the following:

1. Size and location of roof accessories specified in this Section.
2. Method of attaching roof accessories to roof or building structure.
3. Other roof-mounted items including mechanical and electrical equipment, ductwork, piping, and conduit.
4. Required clearances.

B. Sample Warranties: For manufacturer's special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For roof accessories to include in operation and maintenance manuals.

1.7 WARRANTY

A. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finishes or replace roof accessories that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Roof accessories shall withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design [**roof curbs**] [**and**] [**equipment supports**] to comply with wind performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Wind-Restraint Performance: As indicated on Drawings.

2.2 ROOF CURBS

A. Roof Curbs: Internally reinforced roof-curb units capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings, bearing continuously on roof structure, and capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints,[**straight sides,**] [**integral metal cant,**] [**stepped integral metal cant raised the thickness of roof insulation,**] and integrally formed deck-mounting flange at perimeter bottom.

B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

C. Supported Load Capacity: <**Insert load requirements**>.

D. Material: [**Zinc-coated (galvanized)**] [**Aluminum-zinc alloy-coated**] steel sheet, [**0.052 inch (1.32 mm)**] [**0.064 inch (1.63 mm)**] [**0.079 inch (2.01 mm)**] <**Insert dimension**> thick.

1. Finish: [**Mill phosphatized**] [**Factory prime coating**] [**Two-coat fluoropolymer**] [**Baked enamel or powder coat**] <**Insert finish**>.
2. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.

E. Material: Aluminum sheet, [**0.090 inch (2.28 mm)**] [**0.125 inch (3.17 mm)**] <**Insert dimension**> thick.

1. Finish: [**Mill**] [**Factory prime coating**] [**Clear anodic**] [**Color anodic**] [**Two-coat fluoropolymer**] [**Baked enamel or powder coat**] <**Insert finish**>.
2. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] [**Light bronze**] [**Medium bronze**] [**Dark bronze**] <**Insert color**>.

F. Material: Stainless-steel sheet, [**0.078 inch (1.98 mm)**] <**Insert dimension**> thick.

1. Finish: [**Manufacturer's standard**] [**No. 2D, directional polish finish**] <**Insert finish**>.

G. Construction:

1. Curb Profile: [**Manufacturer's standard**] [**Profile as indicated on Drawings**] compatible with roofing system.
2. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
3. Fabricate curbs to minimum height of [**12 inches (305 mm)**] <**Insert dimension**> above roofing surface unless otherwise indicated.
4. Top Surface: Level top of curb, with roof slope accommodated [**by sloping deck-mounting flange**] [**or**] [**by use of leveler frame**].

5. Sloping Roofs: Where roof slope exceeds 1:48, fabricate curb with perimeter curb height tapered to accommodate roof slope so that top surface of perimeter curb is level. Equip unit with water diverter or cricket on side that obstructs water flow.
6. Insulation: Factory insulated with [**1-1/2-inch- (38-mm-)**] <**Insert dimension**> thick glass-fiber board insulation.
7. Liner: Same material as curb, of manufacturer's standard thickness and finish.
8. Nailer: Factory-installed wood nailer [**along top flange of curb**] [**under top flange on side of curb**], continuous around curb perimeter.
9. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb, of size and spacing required to meet wind uplift requirements.
10. Platform Cap: Where portion of roof curb is not covered by equipment, provide weathertight platform cap formed from 3/4-inch (19-mm) thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
11. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as curb.
12. Security Grille: [**Provide for all units**] [**Provide where indicated**].
13. Damper Tray: Provide damper tray or shelf with opening [**3 inches (76 mm)**] <**insert dimension**> [**less than interior curb dimensions indicated**] [**of size indicated**].

2.3 EQUIPMENT SUPPORTS

A. Equipment Supports: [**Internally reinforced perimeter**] [**Rail-type**] metal equipment supports capable of supporting superimposed live and dead loads between structural supports, including equipment loads and other construction indicated on Drawings, spanning between structural supports; capable of meeting performance requirements; with welded[**or mechanically fastened and sealed**] corner joints,[**integral metal cant,**] [**stepped integral metal cant raised the thickness of roof insulation,**] and integrally formed structure-mounting flange at bottom.

B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

C. Supported Load Capacity: <**Insert load requirements**>.

D. Material: [**Zinc-coated (galvanized)**] [**Aluminum-zinc alloy-coated**] steel sheet, [**0.052 inch (1.32 mm)**] [**0.064 inch (1.63 mm)**] [**0.079 inch (2.01 mm)**] <**Insert dimension**> thick.

1. Finish: [**Mill phosphatized**] [**Factory prime coating**] [**Two-coat fluoropolymer**] [**Baked enamel or powder coat**] <**Insert finish**>.
2. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.

E. Material: Aluminum sheet, [**0.090 inch (2.28 mm)**] [**0.125 inch (3.17 mm)**] <**Insert dimension**> thick.

1. Finish: [**Mill**] [**Factory prime coating**] [**Clear anodic**] [**Color anodic**] [**Two-coat fluoropolymer**] [**Baked enamel or powder coat**] <**Insert finish**>.
2. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] [**Light bronze**] [**Medium bronze**] [**Dark bronze**] <**Insert color**>.

F. Material: Stainless-steel sheet, [**0.078 inch (1.98 mm)**] <**Insert dimension**> thick.

1. Finish: [**Manufacturer's standard**] [**No. 2D, directional polish finish**] <**Insert finish**>.

G. Construction:

1. Curb Profile: [**Manufacturer's standard**] [**Profile as indicated on Drawings**] compatible with roofing system.
2. Insulation: Factory insulated with [**1-1/2-inch- (38-mm-)**] <**Insert dimension**> thick glass-fiber board insulation.
3. Liner: Same material as equipment support, of manufacturer's standard thickness and finish.
4. Nailer: Factory-installed continuous wood nailers [**3-1/2 inches (90 mm)**] [**5-1/2 inches (140 mm)**] <**Insert dimension**> wide [**on top flange of equipment supports**] [**under top flange on side of curb**], continuous around support perimeter.
5. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb of size and spacing required to meet wind uplift requirements.
6. Platform Cap: Where portion of equipment support is not covered by equipment, provide weathertight platform cap formed from 3/4-inch (19-mm) thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
7. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as equipment support.
8. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
9. Fabricate equipment supports to minimum height of [**12 inches (305 mm)**] <**Insert dimension**> above roofing surface unless otherwise indicated.
10. Sloping Roofs: Where roof slope exceeds 1:48, fabricate each support with height to accommodate roof slope so that tops of supports are level with each other. Equip supports with water diverters or crickets on sides that obstruct water flow.
11. Security Grille: [**Provide for all units**] [**Provide where indicated on Drawings**].

2.4 PIPE PORTALS

A. Curb-Mounted Pipe Portal: Insulated roof-curb units with welded or mechanically fastened and sealed corner joints,[**straight sides,**] [**integral metal cant,**] [**stepped**

integral metal cant raised the thickness of roof insulation,] and integrally formed deck-mounting flange at perimeter bottom; with weathertight curb cover with single or multiple collared openings and pressure-sealed conically shaped EPDM protective rubber caps sized for piping indicated, with stainless-steel snaplock swivel clamps.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Flashing Pipe Portal: Formed aluminum membrane-mounting flashing flange and sleeve with collared opening and pressure-sealed conically shaped EPDM protective rubber cap sized for piping indicated, with stainless-steel snaplock swivel clamps.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2.5 PREFORMED FLASHING SLEEVES

A. Exhaust Vent Flashing: Double-walled metal flashing sleeve or boot, insulation filled, with integral deck flange, [**12 inches (300 mm)**] <**Insert dimension**> high, with removable metal hood and [**slotted**] [**perforated**] metal collar.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Metal: Aluminum sheet, [**0.063 inch (1.60 mm)**] <**Insert thickness**> thick.
3. Diameter: [**As indicated on Drawings**] [**3 inches (76 mm)**] [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**6 inches (150 mm)**] [**7 inches (175 mm)**] [**8 inches (200 mm)**] [**9 inches (225 mm)**] [**10 inches (250 mm)**] <**Insert dimension**>.
4. Finish: [**Manufacturer's standard**] <**Insert finish**>.

B. Vent Stack Flashing: Metal flashing sleeve, uninsulated, with integral deck flange.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Metal: [**Aluminum sheet, 0.063 inch (1.60 mm) thick**] <**Insert material and thickness**>.
3. Height: [**7 inches (175 mm)**] [**13 inches (330 mm)**] [**19 inches (480 mm)**] <**Insert dimension**>.
4. Diameter: [**As indicated on Drawings**] [**2 inches (50 mm)**] [**3 inches (76 mm)**] [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**6 inches (150 mm)**] <**Insert dimension**>.
5. Finish: [**Manufacturer's standard**] <**Insert finish**>.

2.6 METAL MATERIALS

A. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation[**and mill phosphatized for field painting where indicated**].

1. Mill-Phosphatized Finish: Manufacturer's standard for field painting.
2. Factory Prime Coating: Where field painting is indicated, apply pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat, with a minimum dry film thickness of 0.2 mil (0.005 mm).
3. Exposed Coil-Coated Finish: Prepainted by the coil-coating process to comply with ASTM A 755/A 755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

    a. Two-Coat Fluoropolymer Finish: AAMA 621. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.

4. Baked-Enamel or Powder-Coat Finish: After cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat to a minimum dry film thickness of 2 mils (0.05 mm).
5. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil (0.013 mm).

B. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, AZ50 (AZM150) coated.

1. Factory Prime Coating: Where field painting is indicated, apply pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat, with a minimum dry film thickness of 0.2 mil (0.005 mm).
2. Exposed Coil-Coated Finish: Prepainted by the coil-coating process to comply with ASTM A 755/A 755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

    a. Two-Coat Fluoropolymer Finish: AAMA 621. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.

3. Baked-Enamel or Powder-Coat Finish: After cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat to a minimum dry film thickness of 2 mils (0.05 mm).
4. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil (0.013 mm).

C. Aluminum Sheet: ASTM B 209 (ASTM B 209M), manufacturer's standard alloy for finish required, with temper to suit forming operations and performance required.

1. Mill Finish: As manufactured.

2. Factory Prime Coating: Where field painting is indicated, apply pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat, with a minimum dry film thickness of 0.2 mil (0.005 mm).
3. Clear Anodic Finish: AAMA 611, [**AA-M12C22A41, Class I, 0.018 mm**] [**AA-M12C22A31, Class II, 0.010 mm**] or thicker.
4. Color Anodic Finish: AAMA 611, [**AA-M12C22A42/A44, Class I, 0.018 mm**] [**AA-M12C22A32/A34, Class II, 0.010 mm**] or thicker.
5. Exposed Coil-Coated Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

    a. Two-Coat Fluoropolymer Finish: AAMA 2605. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.

6. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
7. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil (0.013 mm).

D. Aluminum Extrusions and Tubes: ASTM B 221 (ASTM B 221M), manufacturer's standard alloy and temper for type of use, finished to match assembly where used; otherwise mill finished.

E. Stainless-Steel Sheet and Shapes: ASTM A 240/A 240M or ASTM A 666, Type 304.

F. Steel Shapes: ASTM A 36/A 36M, hot-dip galvanized according to ASTM A 123/A 123M unless otherwise indicated.

G. Steel Tube: ASTM A 500/A 500M, round tube.

H. Galvanized-Steel Tube: ASTM A 500/A 500M, round tube, hot-dip galvanized according to ASTM A 123/A 123M.

I. Steel Pipe: ASTM A 53/A 53M, galvanized.

2.7 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.

B. Acrylic Glazing: ASTM D 4802, thermoformable, monolithic sheet, manufacturer's standard, Type UVA (formulated with UV absorber), Finish 1 (smooth or polished).

C. Polycarbonate Glazing: Thermoformable, monolithic polycarbonate sheets manufactured by extrusion process, burglar-resistance rated according to UL 972 with

an average impact strength of [**12 to 16 ft-lbf/in. (640 to 854 J/m)**] <**Insert value**> of width when tested according to ASTM D 256, Method A (Izod).

D. Cellulosic-Fiber Board Insulation: ASTM C 208, Type II, Grade 1, thickness as indicated.

E. Glass-Fiber Board Insulation: ASTM C 726, nominal density of 3 lb/cu. ft. (48 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C), thickness as indicated.

F. Polyisocyanurate Board Insulation: ASTM C 1289, thickness and thermal resistivity as indicated.

G. Wood Nailers: Softwood lumber, pressure treated with waterborne preservatives for aboveground use, acceptable to authorities having jurisdiction,[**containing no arsenic or chromium,**] and complying with AWPA C2; not less than 1-1/2 inches (38 mm) thick.

H. Security Grilles: [**3/4-inch (19-mm)**] <**Insert dimension**> diameter, ASTM A 1011/A 1011M steel bars spaced [**6 inches (150 mm)**] <**Insert dimension**> o.c. in one direction and [**12 inches (300 mm)**] <**Insert dimension**> o.c. in the other; factory finished as follows:

1. Surface Preparation: Remove mill scale and rust, if any, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Factory Priming for Field-Painted Finish: Apply shop primer specified below immediately after surface preparation and pretreatment.
3. Shop Primer: Manufacturer's or fabricator's standard, fast-curing, lead- and chromate-free, universal primer; selected for resistance to normal atmospheric corrosion, for compatibility with substrate and field-applied finish paint system indicated, and for capability to provide a sound foundation for field-applied topcoats under prolonged exposure.

I. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

J. Underlayment:

1. Felt: ASTM D 226/D 226M, Type II (No. 30), asphalt-saturated organic felt, nonperforated.
2. Polyethylene Sheet: 6-mil- (0.15-mm-) thick polyethylene sheet complying with ASTM D 4397.
3. Slip Sheet: Building paper, 3 lb/100 sq. ft. (0.16 kg/sq. m) minimum, rosin sized.
4. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils (0.76 to 1.0 mm) thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.

5. Fasteners: Roof accessory manufacturer's recommended fasteners suitable for application and metals being fastened. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners. Furnish the following unless otherwise indicated:
6. Fasteners for Zinc-Coated or Aluminum-Zinc Alloy-Coated Steel: Series 300 stainless steel or hot-dip zinc-coated steel according to ASTM A 153/A 153M or ASTM F 2329.
7. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
8. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.

K. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, PVC, or silicone or a flat design of foam rubber, sponge neoprene, or cork.

L. Elastomeric Sealant: ASTM C 920, elastomeric [**polyurethane**] [**silicone**] polymer sealant as recommended by roof accessory manufacturer for installation indicated; low modulus; of type, grade, class, and use classifications required to seal joints and remain watertight.

M. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for expansion joints with limited movement.

2.8 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.

B. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.

C. Verify dimensions of roof openings for roof accessories.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install roof accessories according to manufacturer's written instructions.

1. Install roof accessories level; plumb; true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.

B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.

1. Coat concealed side of [**uncoated aluminum**] [**stainless-steel**] roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
2. Underlayment: Where installing roof accessories directly on cementitious or wood substrates, install a course of underlayment and cover with manufacturer's recommended slip sheet.
3. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof accessories for waterproof performance.

C. Roof Curb Installation: Install each roof curb so top surface is level.

D. Equipment Support Installation: Install equipment supports so top surfaces are level with each other.

3.3 REPAIR AND CLEANING

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A 780/A 780M.

B. Touch up factory-primed surfaces with compatible primer ready for field painting according to Section 099113 "Exterior Painting."

C. Clean exposed surfaces according to manufacturer's written instructions.

D. Clean off excess sealants.

E. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION 077200

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SECTION 078100 - APPLIED FIREPROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes sprayed fire-resistive materials.

1.3 DEFINITIONS

A. SFRM: Sprayed fire-resistive materials.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review products, design ratings, restrained and unrestrained conditions, densities, thicknesses, bond strengths, and other performance requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.2: For paints and coatings, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4.2: For paints and coatings, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Shop Drawings: Framing plans or schedules, or both, indicating the following:

1. Extent of fireproofing for each construction and fire-resistance rating.

2. Applicable fire-resistance design designations of a qualified testing and inspecting agency acceptable to authorities having jurisdiction.
3. Minimum fireproofing thicknesses needed to achieve required fire-resistance rating of each structural component and assembly.
4. Treatment of fireproofing after application.

D. Samples: For each exposed product and for each color and texture specified, **i**n manufacturer's standard dimensions in size.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Product Certificates: For each type of fireproofing.

C. Evaluation Reports: For fireproofing, from ICC-ES.

D. Preconstruction Test Reports: For fireproofing.

E. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A firm or individual certified, licensed, or otherwise qualified by fireproofing manufacturer as experienced and with sufficient trained staff to install manufacturer's products according to specified requirements.

B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects, to set quality standards for materials and execution, and for preconstruction testing.

1. Build mockup of each type of fireproofing and different substrate and each required finish as shown on Drawings.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on fireproofing.

B. Preconstruction Adhesion and Compatibility Testing: Test for compliance with requirements for specified performance and test methods.

1. Bond Strength: Test for cohesive and adhesive strength according to ASTM E 736. Provide bond strength indicated in referenced fire-resistance design, but not less than minimum specified in Part 2.
2. Density: Test for density according to ASTM E 605. Provide density indicated in referenced fire-resistance design, but not less than minimum specified in Part 2.
3. Verify that manufacturer, through its own laboratory testing or field experience, attests that primers or coatings are compatible with fireproofing.
4. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
5. For materials failing tests, obtain applied-fireproofing manufacturer's written instructions for corrective measures including the use of specially formulated bonding agents or primers.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Do not apply fireproofing when ambient or substrate temperature is 44 deg F (7 deg C) or lower unless temporary protection and heat are provided to maintain temperature at or above this level for 24 hours before, during, and for 24 hours after product application.

B. Ventilation: Ventilate building spaces during and after application of fireproofing, providing complete air exchanges according to manufacturer's written instructions. Use natural means or, if they are inadequate, forced-air circulation until fireproofing dries thoroughly.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Assemblies: Provide fireproofing, including auxiliary materials, according to requirements of each fire-resistance design and manufacturer's written instructions.

B. Source Limitations: Obtain fireproofing for each fire-resistance design from single source.

C. Fire-Resistance Design: Indicated on Drawings, tested according to ASTM E 119 or UL 263; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Steel members are to be considered unrestrained unless specifically noted otherwise.

D. VOC Content: Applied products shall comply with VOC content limits of authorities having jurisdiction and the following VOC limits:

1. Flat Paints and Coatings: 50 g/L.

2. Nonflat Paints and Coatings: 150 g/L.
3. Primers, Sealers, and Undercoaters: 200 g/L.

E. Asbestos: Provide products containing no detectable asbestos.

2.2 SPRAYED FIRE-RESISTIVE MATERIALS

A. Sprayed Fire-Resistive Material: Manufacturer's standard, factory-mixed, cementitious, medium-weight, dry formulation, complying with indicated fire-resistance design, and mixed with water at Project site to form a slurry or mortar before conveyance and application.

1. Manufacturers:

    a. W.R. Grace MonoCote Z106 HY
    b. Carboline CO Pyrocrete 239
    c. Isolatek Cafco BlazeShield HP
    d. Southwest Fireproofing 7 GP.

2. Bond Strength: Minimum 2000 lbf/sq.ft. cohesive and adhesive strength based on field testing according to ASTM E 736.
3. Density: 22 PCF minimum but not less than density specified in the approved fire-resistance design, according to ASTM E 605.
4. Thickness: As required for fire-resistance design indicated, measured according to requirements of fire-resistance design or ASTM E 605, whichever is thicker, but not less than 0.375 inch (9 mm).
5. Combustion Characteristics: ASTM E 136.
6. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

    a. Flame-Spread Index: 10 or less.
    b. Smoke-Developed Index: 10 or less.

7. Compressive Strength: Minimum 100 lbf/sq. in. (689 kPa) according to ASTM E 761.
8. Corrosion Resistance: No evidence of corrosion according to ASTM E 937.
9. Deflection: No cracking, spalling, or delamination according to ASTM E 759.
10. Effect of Impact on Bonding: No cracking, spalling, or delamination according to ASTM E 760.
11. Air Erosion: Maximum weight loss of 0.025 g/sq. ft. (0.270 g/sq. m) in 24 hours according to ASTM E 859.
12. Fungal Resistance: Treat products with manufacturer's standard antimicrobial formulation to result in no growth on specimens per ASTM G 21.
13. Sound Absorption: NRC of 0.50 to 0.75 according to ASTM C 423 for Type A mounting according to ASTM E 795.
14. Finish: Spray-textured finish.

a. Color: Match Architect's sample.

2.3 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that are compatible with fireproofing and substrates and are approved by UL or another testing and inspecting agency acceptable to authorities having jurisdiction for use in fire-resistance designs indicated.

B. Substrate Primers: Primers approved by fireproofing manufacturer and complying with one or both of the following requirements:

1. Primer and substrate are identical to those tested in required fire-resistance design by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
2. Primer's bond strength in required fire-resistance design complies with specified bond strength for fireproofing and with requirements in UL's "Fire Resistance Directory" or in the listings of another qualified testing agency acceptable to authorities having jurisdiction, based on a series of bond tests according to ASTM E 736.

C. Bonding Agent: Product approved by fireproofing manufacturer and complying with requirements in UL's "Fire Resistance Directory" or in the listings of another qualified testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for substrates and other conditions affecting performance of the Work and according to each fire-resistance design.

1. Verify that substrates are free of dirt, oil, grease, release agents, rolling compounds, mill scale, loose scale, incompatible primers, paints, and encapsulants, or other foreign substances capable of impairing bond of fireproofing with substrates under conditions of normal use or fire exposure.
2. Verify that objects penetrating fireproofing, including clips, hangers, support sleeves, and similar items, are securely attached to substrates.
3. Verify that substrates receiving fireproofing are not obstructed by ducts, piping, equipment, or other suspended construction that will interfere with fireproofing application.

B. Verify that concrete work on steel deck is complete before beginning fireproofing work.

C. Verify that roof construction, installation of rooftop HVAC equipment, and other related work are complete before beginning fireproofing work.

D. Conduct tests according to fireproofing manufacturer's written instructions to verify that substrates are free of substances capable of interfering with bond.

E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Cover other work subject to damage from fallout or overspray of fireproofing materials during application.

B. Clean substrates of substances that could impair bond of fireproofing.

C. Prime substrates where included in fire-resistance design and where recommended in writing by fireproofing manufacturer unless compatible shop primer has been applied and is in satisfactory condition to receive fireproofing.

D. For applications visible on completion of Project, repair substrates to remove surface imperfections that could affect uniformity of texture and thickness in finished surface of fireproofing. Remove minor projections and fill voids that would telegraph through fire-resistive products after application.

3.3 APPLICATION

A. Construct fireproofing assemblies that are identical to fire-resistance design indicated and products as specified, tested, and substantiated by test reports; for thickness, primers, sealers, topcoats, finishing, and other materials and procedures affecting fireproofing work.

B. Comply with fireproofing manufacturer's written instructions for mixing materials, application procedures, and types of equipment used to mix, convey, and apply fireproofing; as applicable to particular conditions of installation and as required to achieve fire-resistance ratings indicated.

C. Coordinate application of fireproofing with other construction to minimize need to cut or remove fireproofing.

1. Do not begin applying fireproofing until clips, hangers, supports, sleeves, and other items penetrating fireproofing are in place.
2. Defer installing ducts, piping, and other items that would interfere with applying fireproofing until application of fireproofing is completed.

D. Metal Decks:

1. Do not apply fireproofing to underside of metal deck substrates until concrete topping, if any, is completed.
2. Do not apply fireproofing to underside of metal roof deck until roofing is completed; prohibit roof traffic during application and drying of fireproofing.

E. Install auxiliary materials as required, as detailed, and according to fire-resistance design and fireproofing manufacturer's written instructions for conditions of exposure and intended use. For auxiliary materials, use attachment and anchorage devices of type recommended in writing by fireproofing manufacturer.

F. Spray apply fireproofing to maximum extent possible. After the spraying operation in each area, complete the coverage by trowel application or other placement method recommended in writing by fireproofing manufacturer.

G. Extend fireproofing in full thickness over entire area of each substrate to be protected.

H. Install body of fireproofing in a single course unless otherwise recommended in writing by fireproofing manufacturer.

I. Where sealers are used, apply products that are tinted to differentiate them from fireproofing over which they are applied.

J. Provide a uniform finish complying with description indicated for each type of fireproofing material and matching finish approved for required mockups.

K. Cure fireproofing according to fireproofing manufacturer's written instructions.

L. Do not install enclosing or concealing construction until after fireproofing has been applied, inspected, and tested and corrections have been made to deficient applications.

M. Finishes: Where indicated, apply fireproofing to produce the following finishes:

1. Spray-Textured Finish: Finish left as spray applied with no further treatment.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Test and inspect as required by the IBC, Subsection 1705.13, "Sprayed Fire-Resistant Materials."

B. Perform the tests and inspections of completed Work in successive stages. Do not proceed with application of fireproofing for the next area until test results for previously completed applications of fireproofing show compliance with requirements. Tested values must equal or exceed values as specified and as indicated and required for approved fire-resistance design.

C. Fireproofing will be considered defective if it does not pass tests and inspections.

1. Remove and replace fireproofing that does not pass tests and inspections, and retest.
2. Apply additional fireproofing, per manufacturer's written instructions, where test results indicate insufficient thickness, and retest.

D. Prepare test and inspection reports.

3.5 CLEANING, PROTECTING, AND REPAIRING

A. Cleaning: Immediately after completing spraying operations in each containable area of Project, remove material overspray and fallout from surfaces of other construction and clean exposed surfaces to remove evidence of soiling.

B. Protect fireproofing, according to advice of manufacturer and Installer, from damage resulting from construction operations or other causes, so fireproofing is without damage or deterioration at time of Substantial Completion.

C. As installation of other construction proceeds, inspect fireproofing and repair damaged areas and fireproofing removed due to work of other trades.

D. Repair fireproofing damaged by other work before concealing it with other construction.

E. Repair fireproofing by reapplying it using same method as original installation or using manufacturer's recommended trowel-applied product.

END OF SECTION 078100

SECTION 078413 - PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Penetrations in fire-resistance-rated walls.
2. Penetrations in horizontal assemblies.

B. Related Sections:

1. Division 01 Section "Quality Requirements" for independent testing agency procedures and administrative requirements.
2. Division 01 Section “Sustainable Design Requirements – LEED for New Construction and Major Renovations” for requirements.
3. Division 07 Section "Joint Firestopping" for joints in or between fire-resistance-rated construction.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittal:

1. Product Data for Credit: For penetration firestopping, including printed statement of VOC content and chemical components.

D. Qualification Data: For qualified Installer.

E. Installer Certificates: From Installer indicating penetration firestopping has been installed in compliance with requirements and manufacturer's written recommendations.

F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for penetration firestopping.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with its "Qualified Firestop Contractor Program Requirements."

B. Installer Qualifications: A firm experienced in installing penetration firestopping similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its penetration firestopping products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.

C. Fire-Test-Response Characteristics: Penetration firestopping shall comply with the following requirements:

1. Penetration firestopping tests are performed by a qualified testing agency acceptable to authorities having jurisdiction.
2. Penetration firestopping is identical to those tested per testing standard referenced in "Penetration Firestopping" Article. Provide rated systems complying with the following requirements:

a. Penetration firestopping products bear classification marking of qualified testing and inspecting agency.
b. Classification markings on penetration firestopping correspond to designations listed by the following:

1) UL in its "Fire Resistance Directory."
2) FM Global in its "Building Materials Approval Guide."

D. Preinstallation Conference: Conduct conference at Project site.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not install penetration firestopping when ambient or substrate temperatures are outside limits permitted by penetration firestopping manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.

B. Install and cure penetration firestopping per manufacturer's written instructions using natural means of ventilations or, where this is inadequate, forced-air circulation.

1.6 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that penetration firestopping is installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate penetration firestopping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. A/D Fire Protection Systems Inc.
2. Grace Construction Products.
3. Hilti, Inc.
4. Johns Manville.
5. Nelson Firestop Products.
6. NUCO Inc.
7. Passive Fire Protection Partners.
8. RectorSeal Corporation.
9. Specified Technologies Inc.
10. 3M Fire Protection Products.
11. Tremco, Inc.; Tremco Fire Protection Systems Group.
12. USG Corporation.

2.2 PENETRATION FIRESTOPPING

A. Provide penetration firestopping that is produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.

B. Penetrations in Fire-Resistance-Rated Walls: Provide penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg .

1. Fire-resistance-rated walls include fire walls, fire-barrier walls, and smoke-barrier walls.
2. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

C. Penetrations in Horizontal Assemblies: Provide penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg .

1. Horizontal assemblies include floors, floor/ceiling assemblies and ceiling membranes of roof/ceiling assemblies.
2. F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.

3. T-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.

D. Exposed Penetration Firestopping: Provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. VOC Content: Provide penetration firestopping that complies with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Architectural Sealants: 250 g/L.
2. Sealant Primers for Nonporous Substrates: 250 g/L.
3. Sealant Primers for Porous Substrates: 775 g/L.

F. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping manufacturer and approved by qualified testing and inspecting agency for firestopping indicated.

1. Permanent forming/damming/backing materials, including the following:

a. Slag-wool-fiber or rock-wool-fiber insulation.
b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
c. Fire-rated form board.
d. Fillers for sealants.

2. Temporary forming materials.
3. Substrate primers.
4. Collars.
5. Steel sleeves.

2.3 FILL MATERIALS

A. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

B. Latex Sealants: Single-component latex formulations that do not re-emulsify after cure during exposure to moisture.

C. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

D. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized-steel sheet.

E. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

F. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.

G. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.

H. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives. Where exposed, cover openings with steel-reinforcing wire mesh to protect pillows/bags from being easily removed.

I. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

J. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces, and nonsag formulation for openings in vertical and sloped surfaces, unless indicated firestopping limits use of nonsag grade for both opening conditions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing penetration firestopping to comply with manufacturer's written instructions and with the following requirements:

1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of penetration firestopping.
2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent penetration firestopping from contacting adjoining surfaces that will remain exposed on completion of the Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove stains. Remove tape as soon as possible without disturbing firestopping's seal with substrates.

3.3 INSTALLATION

A. General: Install penetration firestopping to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestopping.

C. Install fill materials for firestopping by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 FIELD QUALITY CONTROL

A. Contractor will engage a qualified testing agency to perform tests and inspections.

B. Where deficiencies are found or penetration firestopping is damaged or removed because of testing, repair or replace penetration firestopping to comply with requirements.

C. Proceed with enclosing penetration firestopping with other construction only after inspection reports are issued and installations comply with requirements.

3.5 CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping is without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping and install new materials to produce systems complying with specified requirements.

END OF SECTION 078413

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SECTION 078443 - JOINT FIRESTOPPING

GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Joints in or between fire-resistance-rated constructions.
2. Joints in smoke barriers.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetrations in fire-resistance-rated walls, horizontal assemblies, and smoke barriers and for wall identification.
2. Section 079500 "Expansion Control" for fire-resistive architectural joint systems.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product Schedule: For each joint firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing agency.

C. Engineering Judgements: Where Project conditions require modification to a qualified testing agency's illustration for a particular joint firestopping system condition, submit illustration, with modifications marked, approved by joint firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each joint firestopping system, for tests performed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that joint firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with UL's "Qualified Firestop Contractor Program Requirements."

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not install joint firestopping systems when ambient or substrate temperatures are outside limits permitted by joint firestopping system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Install and cure joint firestopping systems per manufacturer's written instructions using natural means of ventilation or, where this is inadequate, forced-air circulation.

1.9 COORDINATION

A. Coordinate construction of joints to ensure that joint firestopping systems can be installed according to specified firestopping system design.

B. Coordinate sizing of joints to accommodate joint firestopping systems.

PART 2 - PRODUCTS

2.1 PERFORMATNCE REQUIREMENTS

A. Fire-Test -Response Characteristics:
   1. Perform joint firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
   2. Test per testing standards referenced in "Joint Firestopping Systems" Article. Provide rated systems complying with the following requirements:
      a. Joint fire stopping systems shall bear classification marking of a qualified testing agency.
      b. UL in its "Fire Resistance Directory."

2.2 JOINT FIRESTOPPING SYSTEMTS

A. Joint Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of assemblies in or between which joint firestopping systems are installed. Joint firestopping systems shall accommodate building movements without impairing their ability to resist the passage of fire and hot gases.

B. Joints in or between Fire-Resistance-Rated Construction: Provide joint firestopping systems with ratings determined per ASTM E 1966 or UL 2079.

1. Joints include those installed in or between fire-resistance-rated walls, floor or floor/ceiling assemblies and roofs or roof/ceiling assemblies.

2. Fire-Resistance Rating: Equal to or exceeding the fire-resistance ratingof construction they will join.

3. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. A/D Fire Protection Systems Inc.
   b. CEMCO.
   c. Fire Trak Corp.
   d. Grace Construction Products.
   e. Hilti, Inc.
   f. Johns Manville
   g. Nelson Firestop Products.
   h. NUCO Inc.
   i. Passive Fire Protection Partners.
   j. RectorSeal Corporation.
   k. Specified Technologies Inc.
   l. 3M Fire Protection Products.
   m. Tremco, Inc.; Tremco Fire Protection Systems Group.
   n. USC Corporation.

C. Fire-Resistance Rating: Equal to or exceeding the fire-resistance rating of the wall, floor, or roof in or between which it is installed.

D. Joints in Smoke Barriers: Provide fire-resistive joint systems with ratings determined per UL 2079 based on testing at a positive pressure differential of 0.30-inch wg.
   1. L-Rating: Not exceeding 5.0 cfm/ft of joint at both ambient and elevated temperatures.
   2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. A/D Fire Protection Systems Inc.
      b. Grace Construction Products.
      c. Hilti, Inc.
      d. Johns Manville
      e. Nelson Firestop Products.
      f. NUCO Inc.
      g. Passive Fire Protection Partners.

h. RectorSeal Corporation.
i. Specified Technologies Inc.
j. 3M Fire Protection Products.
k. Tremco, Inc.; Tremco Fire Protection Systems Group.
l. USC Corporation.

E. Exposed Joint Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

F. Accessories: Provide components of fire-resistive joint systems, including primers and forming materials, that are needed to install elastomeric fill materials and to maintain ratings required. Use only components specified by joint firestopping system manufacturer and approved by the qualified testing agency for conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for joint configurations, substrates, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Before installing fire-resistive joint systems, clean joints immediately to comply with fire-resistive joint system manufacturer's written instructions and the following requirements:
1. Remove from surfaces of joint substrates foreign materials that could interfere with adhesion of elastomeric fill materials or compromise fire-resistive rating.
2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with elastomeric fill materials. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form-release agents from concrete.

B. Prime substrates where recommended in writing by joint firestopping system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

3.3 INSTALLATION

A. General: Install fire-resistive joint systems to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming materials and other accessories of types required to support elastomeric fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing elastomeric fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of fire-resistive joint system.

C. Install elastomeric fill materials for fire-resistive joint systems by proven techniques to produce the following results:
1. Elastomeric fill voids and cavities formed by joints and forming materials as required to achieve fire-resistance ratings indicated.
2. Apply elastomeric fill materials so they contact and adhere to substrates formed apply by joints.
3. For elastomeric fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 FIELD QUALITY CONTROL

A. Inspecting Agency: Owner will engage a qualified testing agency to perform tests and inspections according to ASTM E 2393.

B. Where deficiencies are found or joint firestopping systems are damaged or removed due to testing, repair or replace joint firestopping systems so they comply with requirements.

C. Proceed with enclosing joint firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

3.5 CLEANING AND PROTECTION

A. Clean off excess elastomeric fill materials adjacent to joints as the Work progresses by methods and with cleaning materials that are approved in writing by joint firestopping system manufacturers and that do not damage materials in which joints occur.

B. Provide final protection and maintain conditions during and after installation that ensure joint firestopping systems are without damage or deterioration at time of Substantial Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated fire-resistive joint systems immediately and install new materials to produce fire-resistive joint systems complying with specified requirements.

END OF SECTION 104413

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SECTION 079100 - PREFORMED JOINT SEALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Preformed, foam joint seals.
2. Precured, extruded-silicone joint seals.

B. Related Requirements:

1. Section 079200 "Joint Sealants" for liquid sealants applied over preformed seals in dual seal systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each preformed joint seal product.

B. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each product exposed to view.

C. Samples for Verification: For each type and color of preformed joint seal required, provide Samples with joint seals in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint seals.

D. Preformed Joint Seal Schedule: Include the following information:

1. Joint seal location and designation.
2. Joint width and movement capability.
3. Joint seal manufacturer and product name.
4. Joint seal color.

1.4 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each preformed joint seal for tests performed by a qualified testing agency.

B. Warranties: For special warranties.

1.5 QUALITY ASSURANCE

A. Mockups: Install mockups of assemblies specified in other Sections that are indicated to receive preformed joint seals specified in this Section. Use materials and installation methods specified in this Section.

1.6 WARRANTY

A. Special Warranty: Installer agrees to repair or replace preformed joint seals that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer agrees to furnish preformed joint seals to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PREFORMED, FOAM JOINT SEALS

A. Preformed, Foam Joint Seal Tape: Manufacturer's standard joint seal manufactured from urethane or EVA (ethylene vinyl acetate) foam with minimum density of 10 lb/cu. ft. (160 kg/cu. m) and impregnated with a nondrying, water-repellent agent. Factory produce in precompressed sizes in roll form to fit joint widths based on design criteria indicated, with factory-applied adhesive for bonding to substrates.

1. Emseal or Wil Seal 6001S.
2. Design Criteria:

a. Nominal Joint Width: As indicated on Drawings.
b. Movement Capability: -25 percent/+25 percent.

3. Joint Seal Color: Black.

2.2 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by preformed-joint-seal manufacturer for joint substrates indicated.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to preformed joint seal manufacturer, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces, and formulated to promote best adhesion to joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with preformed joint seals and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive preformed joint seals, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting preformed-joint seal performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing preformed joint seals to comply with preformed joint seal manufacturer's written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of preformed joint seal, including dust, paints (except for permanent protective coatings tested and approved for seal adhesion and compatibility by seal manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimal bond with preformed joint seals. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:

    a. Concrete.
    b. Masonry.

3. Remove laitance and form-release agents from concrete.

4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint seals. Nonporous joint substrates include the following:

    a. Metal.

B. Joint Priming: Prime joint substrates where recommended by preformed joint seal manufacturer or as indicated by tests or prior experience. Apply primer to comply with joint seal manufacturer's written instructions. Confine primers to areas of joint seal bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of adhesive or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION

A. General: Comply with preformed joint seal manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Installation of Preformed, Foam Joint Seals:

1. Install each length of seal immediately after removing protective wrapping.
2. Firmly secure compressed joint seals to joint gap side to obtain full bond using exposed pressure-sensitive adhesive as recommended by manufacturer.
3. Do not pull or stretch material. Produce seal continuity at splices, ends, turns, and intersections of joints.
4. For applications at low ambient temperatures, heat foam joint seal material in compliance with manufacturer's written instructions.

3.4 PROTECTION

A. Protect preformed joint seals from damage resulting from construction operations or other causes so seals are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated seals immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION 079100

SECTION 079200 - JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Silicone joint sealants.
2. Urethane joint sealants.
3. Mildew-resistant joint sealants.
4. Butyl joint sealants.
5. Latex joint sealants.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For sealants and sealant primers used inside the weatherproofing system, documentation including printed statement of VOC content.

C. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

D. Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Product Test Reports: For each kind of joint sealant, for tests performed by a qualified testing agency.

C. Preconstruction Field-Adhesion-Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.

D. Field-Adhesion-Test Reports: For each sealant application tested.

E. Sample Warranties: For special warranties.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Product Testing: Test joint sealants using a qualified testing agency.

1. Testing Agency Qualifications: Qualified according to ASTM C 1021 to conduct the testing indicated.

C. Mockups: Install sealant in mockups of assemblies specified in other Sections that are indicated to receive joint sealants specified in this Section. Use materials and installation methods specified in this Section.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates as follows:

1. Locate test joints where indicated on Project or, if not indicated, as directed by Architect.
2. Conduct field tests for each kind of sealant and joint substrate.
3. Notify Architect seven days in advance of dates and times when test joints will be erected.
4. Arrange for tests to take place with joint-sealant manufacturer's technical representative present.

a. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1.1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.

1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.

5. Report whether sealant failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.
6. Evaluation of Preconstruction Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

1.8 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C).
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.9 WARRANTY

A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer agrees to furnish joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: 20 years from date of Substantial Completion.

C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:

1. Movement of the structure caused by stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
2. Disintegration of joint substrates from causes exceeding design specifications.
3. Mechanical damage caused by individuals, tools, or other outside agents.

4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 JOINT SEALANTS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

B. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following:

1. Architectural sealants shall have a VOC content of 250 g/L or less.
2. Sealants and sealant primers for nonporous substrates shall have a VOC content of 250 g/L or less.
3. Sealants and sealant primers for nonporous substrates shall have a VOC content of 775 g/L or less.

C. Colors of Exposed Joint Sealants: Match Architect's samples.

2.2 SILICONE JOINT SEALANTS

A. Silicone, S, NS, 50, NT, G, M, A, O: Single-component, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade NS, Class 50, Use NT.

2.3 URETHANE JOINT SEALANTS

A. Urethane, M, P, 50, T, NT: Multicomponent, pourable, plus 50 percent and minus 50 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C 920, Type M, Grade P, Class 50, Uses T and NT.

B. Urethane, S, NS, 25, NT: Single-component, nonsag, nontraffic-use, plus 25 percent and minus 25 percent movement capability, urethane joint sealant; ASTM C 920, Type S, Grade NS, Class 25, Use NT.

C. Urethane, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT.

D. Urethane, M, NS, 50, NT: Multicomponent, nonsag, plus 50 percent and minus 50 percent movement capability nontraffic-use, urethane joint sealant; ASTM C 920, Type M, Grade NS, Class 50, Use NT.

2.4 MILDEW-RESISTANT JOINT SEALANTS

A. Mildew-Resistant Joint Sealants: Formulated for prolonged exposure to humidity with fungicide to prevent mold and mildew growth.

B. Silicone, Mildew Resistant, Acid Curing, S, NS, 25, NT: Mildew-resistant, single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, acid-curing silicone joint sealant; ASTM C 920, Type S, Grade NS, Class 25, Use NT.

2.5 BUTYL JOINT SEALANTS

A. Butyl-Rubber-Based Joint Sealants: ASTM C 1311.

2.6 LATEX JOINT SEALANTS

A. Acrylic Latex: Acrylic latex or siliconized acrylic latex, ASTM C 834, Type OP, Grade NF.

2.7 JOINT-SEALANT BACKING

A. Sealant Backing Material, General: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

B. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin), and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.8 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:

    a. Concrete.
    b. Masonry.
    c. Unglazed surfaces of ceramic tile.
    d. Pre-cast concrete.

3. Remove laitance and form-release agents from concrete.
4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:

    a. Metal.

b. Glass.
c. Porcelain enamel.
d. Glazed surfaces of ceramic tile.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of sealant backings.
2. Do not stretch, twist, puncture, or tear sealant backings.
3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.

D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:

1. Place sealants so they directly contact and fully wet joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

1. Remove excess sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
3. Provide concave joint profile per Figure 8A in ASTM C 1193 unless otherwise indicated.

3.4 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:

1. Extent of Testing: Test completed and cured sealant joints as follows:

    a. Perform 10 tests for the first 1000 feet (300 m) of joint length for each kind of sealant and joint substrate.
    b. Perform one test for each 1000 feet (300 m) of joint length thereafter or one test per each floor per elevation.

2. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.

    a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.

3. Inspect tested joints and report on the following:

    a. Whether sealants filled joint cavities and are free of voids.
    b. Whether sealant dimensions and configurations comply with specified requirements.
    c. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion complies with sealant manufacturer's field-adhesion hand-pull test criteria.

4. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant material, sealant configuration, and sealant dimensions.
5. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

B. Evaluation of Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to

comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.5 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.7 JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Exterior joints in horizontal traffic surfaces.

1. Joint Locations:

    a. Control and expansion joints in brick pavers.
    b. Isolation and contraction joints in cast-in-place concrete slabs.
    c. Joints between plant-precast architectural concrete paving units.
    d. Joints in stone paving units, including steps.
    e. Joints between different materials listed above.
    f. Other joints as indicated on Drawings.

2. Joint Sealant: Urethane, M, P, 100/50, T, NT.
3. Joint-Sealant Color: Match Architect's sample.
4. Basis-of-Design: Tremco Vulkem 445SSL.

B. Joint Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces.

1. Joint Locations:

    a. Joints between metal and metal.
    b. Other joints as indicated on Drawings.

2. Joint Sealant: Silicone, S, NS, 50, NT, G, A, O.
3. Joint-Sealant Color: Match Architect's sample.
4. Basis-of-Design: Dow 795.

C. Joint Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces.

1. Joint Locations:

a. Construction joints in cast-in-place concrete.
b. Joints between plant-precast architectural concrete units.
c. Joints between different materials listed above.
d. Perimeter joints between materials listed above and frames of doors, windows, and louvers.
e. Other joints as indicated on Drawings.

2. Joint Sealant: Silicone, nonstaining, S, NS, 50, NT, G, M, A, O.
3. Joint Sealant Color: Match Architect’s sample.
4. Basis-of-Design: Dow 756.

D. Joint-Sealant Application: Interior joints in horizontal traffic surfaces.

1. Joint Locations:

a. Isolation joints in cast-in-place concrete slabs.
b. Control and expansion joints in tile flooring.
c. Other joints as indicated on Drawings.

2. Joint Sealant: Urethane, S, P, 35, T, NT.
3. Joint-Sealant Color: Match Architect's sample.
4. Basis-of-Design: Tremco Vulkem 45 SSL.

E. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces.

1. Joint Locations:

a. Vertical joints on exposed surfaces of unit masonry, walls, and partitions.
b. Other joints as indicated on Drawings.

2. Joint Sealant: Urethane, S, NS, 35, NT.
3. Joint-Sealant Color: Match Architect's sample.
4. Basis-of-Design: Tremco Dymonic FC.

F. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces not subject to significant movement.

1. Joint Locations:

a. Perimeter joints between interior wall surfaces and frames of interior doors, windows, and elevator entrances.
b. Other joints as indicated on Drawings.

2. Joint Sealant: Siliconized Acrylic latex.
3. Joint-Sealant Color: Match Architect's sample.
4. Basis-of-Design: Tremco Tremglaze SA 1100.

G. Joint-Sealant Application: Mildew-resistant interior joints in vertical surfaces and horizontal nontraffic surfaces.

1. Joint Locations:

a. Joints between plumbing fixtures and adjoining walls, floors, and counters.
b. Tile control and expansion joints where indicated.
c. Other joints as indicated on Drawings.

2. Joint Sealant: Silicone, mildew resistant, acid curing, S, NS, 25, NT.
3. Joint-Sealant Color: Match Architect's sample.
4. Basis-of-Design: Dow 786.

END OF SECTION 079200

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SECTION 079500 - EXPANSION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Exterior wall expansion control systems.

B. Related Requirements:

1. Section 079200 "Joint Sealants" for liquid-applied joint sealants and for elastomeric sealants without metal frames.

1.3 ACTION SUBMITTALS

A. Shop Drawings: For each expansion control system specified. Include plans, elevations, sections, details, splices, blockout requirement, attachments to other work, and line diagrams showing entire route of each expansion control system. Where expansion control systems change planes, provide isometric or clearly detailed drawing depicting how components interconnect.

B. Samples: For each exposed expansion control system and for each color and texture specified, full width by 6 inches (150 mm) long in size.

C. Product Schedule: Prepared by or under the supervision of the supplier. Include the following information in tabular form:

1. Manufacturer and model number for each expansion control system.
2. Expansion control system location cross-referenced to Drawings.
3. Nominal joint width.
4. Movement capability.
5. Classification as thermal or seismic.
6. Materials, colors, and finishes.
7. Product options.
8. Fire-resistance ratings.

1.4 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each fire barrier provided as part of an expansion control system, for tests performed by a qualified testing agency.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. General: Provide expansion control systems of design, basic profile, materials, and operation indicated. Provide units with capability to accommodate variations in adjacent surfaces.

1. Furnish units in longest practicable lengths to minimize field splicing. Install with hairline mitered corners where expansion control systems change direction or abut other materials.
2. Include factory-fabricated closure materials and transition pieces, T-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous expansion control systems.

B. Coordination: Coordinate installation of exterior wall and soffit expansion control systems with roof expansion control systems to ensure that wall transitions are watertight. Roof expansion joint assemblies are specified elsewhere.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Expansion control systems shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor is 1.5.

2.3 EXTERIOR WALL EXPANSION CONTROL SYSTEMS

A. Source Limitations: Obtain expansion control systems from single source from single manufacturer.

B. Wall-to-Wall:

1. Basis-of-Design Product: CS Group VF Series.
2. Design Criteria:

a. Nominal Joint Width: As indicated on Drawings.

3. Type: Preformed cellular foam.

a. Foam Material: Low-modulus silicone with an open cell polyurethane foam.

1) Color: Match Architect’s sample.

2.4 MATERIALS

A. Cellular Foam Seals: Extruded, compressible foam designed to function under compression.

B. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

C. Accessories: Manufacturer's standard anchors, clips, fasteners, set screws, spacers, and other accessories compatible with material in contact, as indicated or required for complete installations.

2.5 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces where expansion control systems will be installed for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to expansion control system manufacturer's written instructions.

B. Coordinate and furnish anchorages, setting drawings, and instructions for installing expansion control systems. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of expansion control systems.

3.3 INSTALLATION

A. Comply with manufacturer's written instructions for storing, handling, and installing expansion control systems and materials unless more stringent requirements are indicated.

B. Foam Seals: Install with adhesive recommended by manufacturer.

1. Miter corner.

C. Terminate exposed ends of expansion control systems with field- or factory-fabricated termination devices.

3.4 PROTECTION

A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.

B. Protect the installation from damage by work of other Sections. Where necessary due to heavy construction traffic, remove and properly store cover plates or seals and install temporary protection over expansion control systems. Reinstall cover plates or seals prior to Substantial Completion of the Work.

END OF SECTION 079500

SECTION 081113 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes hollow-metal work.

B. Related Requirements:

1. Section 087100 "Door Hardware" for door hardware for hollow-metal doors.

1.3 DEFINITIONS

A. Minimum Thickness: Minimum thickness of base metal without coatings according to NAAMM-HMMA 803 or SDI A250.8.

1.4 COORDINATION

A. Coordinate anchorage installation for hollow-metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, core descriptions, fire-resistance ratings, temperature-rise ratings, and finishes.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Shop Drawings: Include the following:

1. Elevations of each door type.
2. Details of doors, including vertical- and horizontal-edge details and metal thicknesses.
3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
4. Locations of reinforcement and preparations for hardware.
5. Details of each different wall opening condition.
6. Details of anchorages, joints, field splices, and connections.
7. Details of accessories.
8. Details of moldings, removable stops, and glazing.
9. Details of conduit and preparations for power, signal, and control systems.

D. Schedule: Provide a schedule of hollow-metal work prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final Door Hardware Schedule.

1.7 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each type of hollow-metal door and frame assembly, for tests performed by a qualified testing agency.

B. Oversize Construction Certification: For assemblies required to be fire rated and exceeding limitations of labeled assemblies.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver hollow-metal work palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.

1. Provide additional protection to prevent damage to factory-finished units.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

C. Store hollow-metal work vertically under cover at Project site with head up. Place on minimum 4-inch- (102-mm-) high wood blocking. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers:

1. Ceco Door Products.
2. Curries Company.
3. Deansteel Manufacturing.
4. Mesker Door, Inc.
5. Pioneer Industries, Inc.
6. Republic Doors & Frames.
7. Steelcraft.

B. Source Limitations: Obtain hollow-metal work from single source from single SDI member manufacturer.

2.2 REGULATORY REQUIREMENTS

A. Fire-Rated Assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.

1. Smoke- and Draft-Control Assemblies: Provide an assembly with gaskets listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.

B. Fire-Rated, Borrowed-Lite Assemblies: Complying with NFPA 80 and listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9.

2.3 INTERIOR DOORS AND FRAMES

A. Construct interior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Extra-Heavy-Duty Doors and Frames: SDI A250.8, Level 3.

1. Physical Performance: Level A according to SDI A250.4.
2. Doors:

a. Type: As indicated in the Door and Frame Schedule.
b. Thickness: 1-3/4 inches (44.5 mm).

c. Face: Uncoated, cold-rolled steel sheet, minimum thickness of 0.053 inch (1.3 mm).
d. Edge Construction: Model 1, Full Flush.

3. Frames:

a. Materials: Uncoated, steel sheet, minimum thickness of 0.053 inch (1.3 mm).
b. Sidelite and Transom Frames: Fabricated from same thickness material as adjacent door frame.
c. Construction: Full profile welded.

4. Exposed Finish: Prime.

2.4 EXTERIOR HOLLOW-METAL DOORS AND FRAMES

A. Construct exterior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Extra-Heavy-Duty Doors and Frames: SDI A250.8, Level 3.

1. Physical Performance: Level A according to SDI A250.4.
2. Doors:

a. Type: As indicated in the Door and Frame Schedule.
b. Thickness: 1-3/4 inches (44.5 mm.)
c. Face: Metallic-coated steel sheet, minimum thickness of 0.053 inch (1.3 mm), with minimum A40 (ZF120) coating.
d. Edge Construction: Model 2, Seamless.
e. Core: Polyurethane or Polyisocyanurate.

1) Thermal-Rated Doors: Provide doors fabricated with thermal-resistance value (R-value) of not less than 2.1 deg F x h x sq. ft./Btu (0.370 K x sq. m/W) when tested according to ASTM C 1363.

3. Frames:

a. Materials: Metallic-coated steel sheet, minimum thickness of 0.053 inch (1.3 mm), with minimum A40 (ZF120) coating.
b. Construction: Full profile welded.

4. Exposed Finish: Prime.

2.5 BORROWED LITES

A. Hollow-metal frames of uncoated steel sheet, minimum thickness of 0.053 inch (1.3 mm).

B. Construction: Full profile welded.

2.6 HOLLOW METAL PANELS

A. Provide hollow metal panels of same materials, construction, and finish as adjacent door assemblies.

2.7 FRAME ANCHORS

A. Jamb Anchors:

1. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.042 inch (1.0 mm) thick, with corrugated or perforated straps not less than 2 inches (51 mm) wide by 10 inches (254 mm) long; or wire anchors not less than 0.177 inch (4.5 mm) thick.
2. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042 inch (1.0 mm) thick.
3. Compression Type for Drywall Slip-on Frames: Adjustable compression anchors.
4. Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch- (9.5-mm-) diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.

B. Floor Anchors: Formed from same material as frames, minimum thickness of 0.042 inch (1.0 mm), and as follows:

1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
2. Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch (51-mm) height adjustment. Terminate bottom of frames at finish floor surface.

2.8 MATERIALS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

C. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

D. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B.

E. Frame Anchors: ASTM A 879/A 879M, Commercial Steel (CS), 04Z (12G) coating designation; mill phosphatized.

1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.

F. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.

G. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.

H. Grout: ASTM C 476, except with a maximum slump of 4 inches (102 mm), as measured according to ASTM C 143/C 143M.

I. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.

J. Glazing: Comply with requirements in Section 088000 "Glazing."

K. Bituminous Coating: Cold-applied asphalt mastic, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.9 FABRICATION

A. Fabricate hollow-metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for metal thickness. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.

B. Hollow-Metal Doors:

1. Steel-Stiffened Door Cores: Provide minimum thickness 0.026 inch (0.66 mm), steel vertical stiffeners of same material as face sheets extending full-door height, with vertical webs spaced not more than 6 inches (152 mm) apart. Spot weld to face sheets no more than 5 inches (127 mm) o.c. Fill spaces between stiffeners with glass- or mineral-fiber insulation.

2. Fire Door Cores: As required to provide fire-protection and temperature-rise ratings indicated.
3. Vertical Edges for Single-Acting Doors: Bevel edges 1/8 inch in 2 inches (3.2 mm in 51 mm).
4. Top Edge Closures: Close top edges of doors with inverted closures, except provide flush closures at exterior doors of same material as face sheets.
5. Bottom Edge Closures: Close bottom edges of doors where required for attachment of weather stripping with end closures or channels of same material as face sheets.
6. Exterior Doors: Provide weep-hole openings in bottoms of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration.
7. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch (19 mm) beyond edge of door on which astragal is mounted or as required to comply with published listing of qualified testing agency.

C. Hollow-Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.

1. Sidelite and Transom Bar Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by butt welding.
2. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
3. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
4. Floor Anchors: Weld anchors to bottoms of jambs with at least four spot welds per anchor; however, for slip-on drywall frames, provide anchor clips or countersunk holes at bottoms of jambs.
5. Jamb Anchors: Provide number and spacing of anchors as follows:

    a. Masonry Type: Locate anchors not more than 16 inches (406 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c., to match coursing, and as follows:

        1) Two anchors per jamb up to 60 inches (1524 mm) high.
        2) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
        3) Four anchors per jamb from 90 to 120 inches (2286 to 3048 mm) high.
        4) Four anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 120 inches (3048 mm) high.

    b. Stud-Wall Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:

1) Three anchors per jamb up to 60 inches (1524 mm) high.
2) Four anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
3) Five anchors per jamb from 90 to 96 inches (2286 to 2438 mm) high.
4) Five anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 96 inches (2438 mm) high.

c. Compression Type: Not less than two anchors in each frame.
d. Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.

6. Head Anchors: Two anchors per head for frames more than 42 inches (1067 mm) wide and mounted in metal-stud partitions.
7. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.

a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

D. Fabricate concealed stiffeners and edge channels from either cold- or hot-rolled steel sheet.

E. Hardware Preparation: Factory prepare hollow-metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to SDI A250.6, the Door Hardware Schedule, and templates.

1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
2. Comply with applicable requirements in SDI A250.6 and BHMA A156.115 for preparation of hollow-metal work for hardware.

F. Stops and Moldings: Provide stops and moldings around glazed lites and louvers where indicated. Form corners of stops and moldings with [**butted**] [**or**] [**mitered**] hairline joints.

1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow-metal work.
2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
3. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
4. Provide loose stops and moldings on inside of hollow-metal work.
5. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.

2.10 STEEL FINISHES

A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.

1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

2.11 ACCESSORIES

A. Louvers: Provide louvers for interior doors, where indicated, which comply with SDI 111C, with blades or baffles formed of 0.020-inch- (0.5-mm-) thick, cold-rolled steel sheet set into 0.032-inch- (0.8-mm-) thick steel frame.

B. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.

C. Grout Guards: Formed from same material as frames, not less than 0.016 inch (0.4 mm) thick.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for embedded and built-in anchors to verify actual locations before frame installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.

B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.3 INSTALLATION

A. General: Install hollow-metal work plumb, rigid, properly aligned, and securely fastened in place. Comply with Drawings and manufacturer's written instructions.

B. Hollow-Metal Frames: Install hollow-metal frames for doors, transoms, sidelites, borrowed lites, and other openings, of size and profile indicated. Comply with SDI A250.11 or NAAMM-HMMA 840 as required by standards specified.

1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.

    a. At fire-rated openings, install frames according to NFPA 80.
    b. Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
    c. Install frames with removable stops located on secure side of opening.
    d. Install door silencers in frames before grouting.
    e. Remove temporary braces necessary for installation only after frames have been properly set and secured.
    f. Check plumb, square, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
    g. Field apply bituminous coating to backs of frames that will be filled with grout containing antifreezing agents.

2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.

    a. Floor anchors may be set with power-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.

3. Coordinate frame fill with hardware installation.
4. Metal-Stud Partitions and Exterior Locations: Solidly pack mineral-fiber insulation inside frames.
5. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout at interior locations.
6. Concrete Walls: Solidly fill space between frames and concrete with mineral-fiber insulation.
7. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
8. Installation Tolerances: Adjust hollow-metal door frames for squareness, alignment, twist, and plumb to the following tolerances:

    a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.

b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.

C. Hollow-Metal Doors: Fit hollow-metal doors accurately in frames, within clearances specified below. Shim as necessary.

1. Non-Fire-Rated Steel Doors:

a. Between Door and Frame Jambs and Head: 1/8 inch (3.2 mm) plus or minus 1/32 inch (0.8 mm).
b. Between Edges of Pairs of Doors: 1/8 inch (3.2 mm) to 1/4 inch (6.3 mm) plus or minus 1/32 inch (0.8 mm).
c. At Bottom of Door: 5/8 inch (15.8 mm) plus or minus 1/32 inch (0.8 mm).
d. Between Door Face and Stop: 1/16 inch (1.6 mm) to 1/8 inch (3.2 mm) plus or minus 1/32 inch (0.8 mm).

2. Fire-Rated Doors: Install doors with clearances according to NFPA 80.
3. Smoke-Control Doors: Install doors and gaskets according to NFPA 105.

D. Glazing: Comply with installation requirements in Section 088000 "Glazing" and with hollow-metal manufacturer's written instructions.

1. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (51 mm) o.c. from each corner.

3.4 ADJUSTING AND CLEANING

A. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow-metal work that is warped, bowed, or otherwise unacceptable.

B. Remove grout and other bonding material from hollow-metal work immediately after installation.

C. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

D. Metallic-Coated Surface Touchup: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.

END OF SECTION 081113

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SECTION 083113 - ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes access doors and frames for walls and ceilings.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for heating and air-conditioning duct access doors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, fire ratings, material descriptions, dimensions of individual components and profiles, and finishes.

B. Product Schedule: For access doors and frames including types, general locations, sizes, construction details, latching or locking provisions and other data pertinent to installation.

1.4 COORDINATION

A. Verification: Determine specific locations and sizes for access doors needed to gain access to concealed equipment and indicate on schedule specified in “Submittals” article.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Rated Access Doors and Frames: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection and temperature-rise limit ratings indicated, according to NFPA 252 or UL 10B.

2.2 ACCESS DOORS AND FRAMES

A. Flush Access Doors with Exposed Flanges

1. Description: Face of door flush with frame, with exposed flange and concealed hinge.
2. Locations: Wall and ceiling.
3. Door Size: As required.
4. Uncoated Steel Sheet for Door: Nominal 0.060 inch (1.52 mm), 16 gage, factory primed.
5. Stainless-Steel Sheet for Door: Nominal 0.062 inch (1.59 mm), 16 gage, at toilet rooms and kitchen areas.
6. Frame Material: Same material, thickness, and finish as door.
7. Latch and Lock: Provide mortise lock to receive cylinder and 7-pin core in Section 087100 Door Hardware.
8. Mounting: Provide mounting holes in frames to attach frames to metal framing in drywall construction and to attach masonry anchors in masonry construction. Furnish adjustable metal masonry anchors.

2.3 FIRE-RATED ACCESS DOORS AND FRAMES

A. Fire-Rated, Flush Access Doors with Exposed Flanges:

1. Description: Door face flush with frame, with a core of mineral-fiber insulation enclosed in sheet metal; with exposed flange, self-closing door, and concealed hinge.
2. Locations: Walls and ceiling.
3. Door Size: As required.
4. Fire-Resistance Rating: Not less than 1-1/2 hours.
5. Uncoated Steel Sheet for Door: Nominal 0.036 inch (0.91 mm), 20 gage, factory primed.
6. Stainless Steel Sheet for Door: Nominal 0.036 inch, 20 gage, No. 4 finish.
7. Frame Material: Same material, thickness, and finish as door.
8. Latch and Lock: Self-latching door hardware. Provide mortise lock to receive cylinder and 7-pin core in Section 087100 Door Hardware.

2.4 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

B. Steel Sheet: Uncoated or electrolytic zinc coated, ASTM A 879/A 879M, with cold-rolled steel sheet substrate complying with ASTM A 1008/A 1008M, Commercial Steel (CS), exposed.

C. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304. Remove tool and die marks and stretch lines, or blend into finish.

D. Frame Anchors: Same material as door face.

E. Inserts, Bolts, and Anchor Fasteners: Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.

2.5 FABRICATION

A. General: Provide access door and frame assemblies manufactured as integral units ready for installation.

B. Metal Surfaces: For metal surfaces exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

C. Doors and Frames: Grind exposed welds smooth and flush with adjacent surfaces. Furnish mounting holes, attachment devices and fasteners of type required to secure access doors to types of supports indicated.

D. Latch and Lock Hardware:

1. Quantity: Furnish number of latches and locks required to hold doors tightly closed.
2. Mortise Cylinder Preparation: Door panel to receive cylinder specified in Section 087100 "Door Hardware.”

2.6 FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

D. Painted Finishes: Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Factory Primed: Apply manufacturer's standard, lead- and chromate-free, universal primer immediately after surface preparation and pretreatment.

E. Stainless-Steel Finishes:

1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finish: No. 4 finish. Grind and polish surfaces to produce uniform finish, free of cross scratches.

a. Run grain of directional finishes with long dimension of each piece.
b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's written instructions for installing access doors and frames.

B. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces.

C. Install access doors true, square and plumb.

3.3 ADJUSTING

A. Adjust doors and hardware, after installation, for proper operation.

END OF SECTION 083113

SECTION 083323 - OVERHEAD COILING DOORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Insulated service doors.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for miscellaneous steel supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of overhead coiling door and accessory.

1. Include construction details, material descriptions, dimensions of individual components, profiles for slats, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.

B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies, and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include points of attachment and their corresponding static and dynamic loads imposed on structure.
4. For exterior components, include details of provisions for assembly expansion and contraction and for excluding and draining moisture to the exterior.
5. Show locations of controls, locking devices and other accessories.
6. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: Manufacturer's finish charts showing full range of colors and textures available for units with factory-applied finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For overhead coiling doors to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer for both installation and maintenance of units required for this Project.

1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

B. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC A117.1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS, GENERAL

A. Source Limitations: Obtain overhead coiling doors from single source from single manufacturer.

1. Obtain operators and controls from overhead coiling door manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Structural Performance, Exterior Doors: Capable of withstanding the design wind loads.

1. Design Wind Load: As indicated on Drawings.
2. Deflection Limits: Design overhead coiling doors to withstand design wind load without evidencing permanent deformation or disengagement of door components.
3. Operability under Wind Load: Design overhead coiling doors to remain operable under design wind load, acting inward and outward.

B. Windborne-Debris Impact Resistance: Provide [**glazed**] [**and**] [**impact-protective**] overhead coiling doors that pass missile-impact and cyclic-pressure tests according to [**ASTM E 1996 for Wind Zone 1**] [**ASTM E 1996 for Wind Zone 2**] [**ASTM E 1996 for Wind Zone 3**] [**ASTM E 1996 for Wind Zone 4**] [**or DASMA 115**] <**Insert requirement**>.

1. Large-Missile Test: For overhead coiling doors located within 30 feet (9.144 m) of grade.
2. Small-Missile Test: For overhead coiling doors located more than 30 feet (9.144 m) above grade.

C. Seismic Performance: Overhead coiling doors shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.

1. Component Importance Factor: [**1.5**] [**1.0**].

2.3 DOOR ASSEMBLY

A. Insulated Service Door: Overhead coiling door formed with curtain of interlocking metal slats.

1. Manufacturers:

a. Cookson.
b. Cornell.
c. Raynor.
d. Wayne-Dalton.

B. Operation Cycles: Door components and operators capable of operating for not less than 20,000. One operation cycle is complete when a door is opened from the closed position to the fully open position and returned to the closed position.

C. Air Infiltration: Maximum rate of 0.08 cfm/sq. ft. (0.406 L/s per sq. m) at 15 and 25 mph (24.1 and 40.2 km/h) when tested according to ASTM E 283.

D. Curtain R-Value: 8.0 deg F x h x sq. ft./Btu.

E. Door Curtain Material: Galvanized steel.

F. Door Curtain Slats: Flat profile slats of 7/8-inch (48-mm) thickness.

1. Vision Panels: Approximately 10- by 1-5/8-inch (254- by 41-mm) openings spaced approximately 2 inches (51 mm) apart and beginning 12 inches (305 mm) from end guides; in three rows of slats at height indicated on Drawings; installed with insulated vision-panel glazing.
2. Insulated-Slat Interior Facing: Metal.
3. Gasket Seal. Manufacturer's standard continuous gaskets between slats.

G. Bottom Bar: Two angles, each not less than 1-1/2 by 1-1/2 by 1/8 inch (38 by 38 by 3 mm) thick; fabricated from hot-dip galvanized steel and finished to match door.

H. Curtain Jamb Guides: Galvanized steel with exposed finish matching curtain slats.

I. Hood: Match curtain material and finish.

1. Shape: Round.
2. Mounting: Face of wall.

J. Locking Devices: Equip door with locking device assembly.

1. Locking Device Assembly: Single-jamb side locking bars, operable from inside and outside with cylinders.

K. Electric Door Operator:

1. Usage Classification: Standard duty, up to 25 cycles per hour and up to 90 cycles per day.
2. Operator Location: Top of hood or Wall.
3. Safety: Listed according to UL 325 by a qualified testing agency for commercial or industrial use; moving parts of operator enclosed or guarded if exposed and mounted at 8 feet (2.44 m) or lower.
4. Motor Exposure: Interior.
5. Emergency Manual Operation: Chain type.
6. Obstruction-Detection Device: Automatic photoelectric sensor.
7. Control Station(s): As indicated on drawings.
8. Other Equipment: Audible and visual signals.
9. Card reader specified under Division 26.

L. Curtain Accessories: Equip door with weatherseals on exterior doors.

M. Door Finish:

1. Baked-Enamel or Powder-Coated Finish: Color matching Architect's sample.
2. Interior Curtain-Slat Facing: Finish matching Architect's sample.

2.4 MATERIALS, GENERAL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.5 DOOR CURTAIN MATERIALS AND CONSTRUCTION

A. Door Curtains: Fabricate overhead coiling-door curtain of interlocking metal slats, designed to withstand wind loading indicated, in a continuous length for width of door

without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door indicated, and as follows:

1. Steel Door Curtain Slats: Zinc-coated (galvanized), cold-rolled structural steel sheet; complying with ASTM A 653/A 653M, with G90 (Z275) zinc coating; nominal sheet thickness (coated) of 0.028 inch (0.71 mm); and as required.
2. Vision-Panel Glazing: Manufacturer's standard clear glazing, fabricated from transparent acrylic sheet or fire-protection rated glass as required for type of door; set in glazing channel secured to curtain slats.
3. Insulation: Fill slats for insulated doors with manufacturer's standard thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E 84 or UL 723. Enclose insulation completely within slat faces.
4. Metal Interior Curtain-Slat Facing: Match metal of exterior curtain-slat face, with minimum steel thickness of 0.010 inch (0.25 mm).

B. Curtain Jamb Guides: Manufacturer's standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent overtravel of curtain, and a continuous bar for holding windlocks.

2.6 HOODS

A. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.

1. Galvanized Steel: Nominal 0.028-inch- (0.71-mm-) thick, hot-dip galvanized steel sheet with G90 (Z275) zinc coating, complying with ASTM A 653/A 653M.
2. Finish: To match door.

2.7 LOCKING DEVICES

A. Locking Device Assembly: Fabricate with cylinder lock, spring-loaded dead bolt, operating handle, cam plate, and adjustable locking bars to engage through slots in tracks.

1. Lock Cylinders: Cylinders specified in Section 087100 "Door Hardware" and keyed to building keying system.

B. Chain Lock Keeper: Suitable for padlock.

C. Safety Interlock Switch: Equip power-operated doors with safety interlock switch to disengage power supply when door is locked.

2.8 CURTAIN ACCESSORIES

A. Weatherseals for Exterior Doors: Equip each exterior door with weather-stripping gaskets fitted to entire exterior perimeter of door for a weather-resistant installation unless otherwise indicated.

1. At door head, use 1/8-inch- (3-mm-) thick, replaceable, continuous-sheet baffle secured to inside of hood or field- installed on the header.
2. At door jambs, use replaceable, adjustable, continuous, flexible, 1/8-inch- (3-mm-) thick seals of flexible vinyl, rubber, or neoprene.

B. Astragal for Interior Doors: Equip each door bottom bar with a replaceable, adjustable, continuous, compressible gasket of flexible vinyl, rubber, or neoprene as a cushion bumper.

2.9 COUNTERBALANCING MECHANISM

A. General: Counterbalance doors by means of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.

B. Counterbalance Barrel: Fabricate spring barrel of manufacturer's standard hot-formed, structural-quality, seamless carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 0.03 in./ft. (2.5 mm/m) of span under full load.

C. Counterbalance Spring: One or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.

D. Torsion Rod for Counterbalance Shaft: Fabricate of manufacturer's standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.

E. Brackets: Manufacturer's standard mounting brackets of either cast iron or cold-rolled steel plate.

2.10 ELECTRIC DOOR OPERATORS

A. General: Electric door operator assembly of size and capacity recommended and provided by door manufacturer for door and operation-cycles requirement specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit,

solenoid-operated brake, clutch, control stations, control devices, integral gearing for locking door, and accessories required for proper operation.

1. Comply with NFPA 70.
2. Control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6, with NFPA 70 Class 2 control circuit, maximum 24-V ac or dc.

B. Usage Classification: Electric operator and components capable of operating for not less than number of cycles per hour indicated for each door.

C. Door Operator Location(s): Operator location indicated for each door.

1. Top-of-Hood Mounted: Operator is mounted to the right or left door head plate with the operator on top of the door-hood assembly and connected to the door drive shaft with drive chain and sprockets. Headroom is required for this type of mounting.
2. Wall Mounted: Operator is mounted to the inside front wall on the left or right side of door and connected to door drive shaft with drive chain and sprockets. Side room is required for this type of mounting. Wall mounted operator can also be mounted above or below shaft; if above shaft, headroom is required.

D. Motors: Reversible-type motor with controller (disconnect switch) for motor exposure indicated.

1. Electrical Characteristics:

   a. Phase: Single phase.
   b. Volts: 208V.
   c. Hertz: 60.

2. Motor Size: Minimum size as indicated. If not indicated, large enough to start, accelerate, and operate door in either direction from any position, at a speed not less than 8 in./sec. (203 mm/s) and not more than 12 in./sec. (305 mm/s), without exceeding nameplate ratings or service factor.
3. Operating Controls, Controllers, Disconnect Switches, Wiring Devices, and Wiring: Manufacturer's standard unless otherwise indicated.
4. Coordinate wiring requirements and electrical characteristics of motors and other electrical devices with building electrical system and each location where installed.

E. Limit Switches: Equip each motorized door with adjustable switches interlocked with motor controls and set to automatically stop door at fully opened and fully closed positions.

F. Obstruction Detection Devices: External entrapment protection consisting of indicated automatic safety sensor capable of protecting full width of door opening. For non-fire-rated doors, activation of device immediately stops and reverses downward door travel.

1. Photoelectric Sensor: Manufacturer's standard system designed to detect an obstruction in door opening without contact between door and obstruction.

G. Control Station: Three-button control station in fixed location with momentary-contact push-button controls labeled "Open" and "Stop" and sustained- or constant-pressure push-button control labeled "Close."

1. Interior-Mounted Units: Full-guarded, surface-mounted, heavy-duty type, with general-purpose NEMA ICS 6, Type 1 enclosure.
2. Exterior-Mounted Units: Full-guarded, surface-mounted, standard-duty type, weatherproof, NEMA ICS 6, Type 4 enclosure, key and card reader operated.

H. Emergency Manual Operation: Equip each electrically powered door with capability for emergency manual operation. Design manual mechanism so required force for door operation does not exceed 25 lbf (111 N).

I. Emergency Operation Disconnect Device: Equip operator with hand-operated disconnect mechanism for automatically engaging manual operator and releasing brake for emergency manual operation while disconnecting motor without affecting timing of limit switch. Mount mechanism so it is accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.

J. Motor Removal: Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency manual operation.

K. Audible and Visual Signals: Audible alarm and visual indicator lights in compliance with regulatory requirements for accessibility.

2.11 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM/NOMMA's "Metal Finishes Manual for Architectural and Metal Products (AMP 500-06)" for recommendations for applying and designating finishes.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.12 STEEL AND GALVANIZED-STEEL FINISHES

A. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates areas and conditions, with Installer present, for compliance with requirements for substrate construction and other conditions affecting performance of the Work.

B. Examine locations of electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install overhead coiling doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.

B. Install overhead coiling doors, hoods, controls, and operators at the mounting locations indicated for each door.

C. Accessibility: Install overhead coiling doors, switches, and controls along accessible routes in compliance with regulatory requirements for accessibility.

D. Power-Operated Doors: Install according to UL 325.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Perform installation and startup checks according to manufacturer's written instructions.

3.4 ADJUSTING

A. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion.

1. Adjust exterior doors and components to be weather-resistant.

B. Lubricate bearings and sliding parts as recommended by manufacturer.

C. Adjust seals to provide tight fit around entire perimeter.

3.5 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of coiling-door Installer. Include quarterly preventive maintenance, repair, or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for door operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Perform maintenance, including emergency callback service, during normal working hours.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain overhead coiling doors.

END OF SECTION 083323

SECTION 084213 - ALUMINUM-FRAMED ENTRANCES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Exterior manual-swing entrance doors and door-frame units.
2. Interior manual-swing entrance doors and door-frame units.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For glazing sealants used inside the weatherproofing system, documentation including printed statement of VOC content.

C. Shop Drawings: For aluminum-framed entrances. Include plans, elevations, sections, full-size details, and attachments to other work.

1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
2. Include full-size isometric details of each vertical-to-horizontal intersection of aluminum-framed entrances, showing the following:

a. Joinery, including concealed welds.
b. Anchorage.

c. Expansion provisions.
d. Glazing.
e. Flashing and drainage.

3. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

D. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.

E. Entrance Door Hardware Schedule: Prepared by or under supervision of supplier, detailing fabrication and assembly of entrance door hardware, as well as procedures and diagrams. Coordinate final entrance door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of entrance door hardware.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and field testing agency.

B. Energy Performance Certificates: For aluminum-framed entrances, accessories, and components, from manufacturer.

1. Basis for Certification: NFRC-certified energy performance values for each aluminum-framed entrance.

C. Product Test Reports: For aluminum-framed entrances.

D. Field quality-control reports.

E. Sample Warranties: For special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For aluminum-framed entrances to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Testing Agency Qualifications: Qualified according to ASTM E 699 for testing indicated.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed entrances that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed entrances representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

B. Structural Loads:

1. Wind Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.

C. Structural: Test according to ASTM E 330 as follows:

1. When tested at positive and negative wind-load design pressures, assemblies do not evidence deflection exceeding specified limits.
2. When tested at 150 percent of positive and negative wind-load design pressures, assemblies, including anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.
3. Test Durations: As required by design wind velocity, but not less than 10 seconds.

D. Air Infiltration: Test according to ASTM E 283 for infiltration as follows:

1. Entrance Doors:

a. Pair of Doors: Maximum air leakage of 1.0 cfm/sq. ft. (5.08 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft. (75 Pa).
b. Single Doors: Maximum air leakage of 0.5 cfm/sq. ft. (2.54 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft. (75 Pa).

E. Water Penetration under Static Pressure: Test according to ASTM E 331 as follows:

1. No evidence of water penetration through fixed glazing and framing areas when tested according to a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft. (300 Pa).

F. Energy Performance: Certify and label energy performance according to NFRC as follows:

1. Thermal Transmittance (U-factor): Fixed glazing and framing areas shall have U-factor of not more than 0.20 Btu/sq. ft. x h x deg F as determined according to NFRC 100.
2. Solar Heat Gain Coefficient: Fixed glazing and framing areas shall have a solar heat gain coefficient of no greater than 0.24 as determined according to NFRC 200.
3. Condensation Resistance: Fixed glazing and framing areas shall have an NFRC-certified condensation resistance rating of no less than 45 as determined according to NFRC 500.

G. Noise Reduction: Test according to ASTM E 90, with ratings determined by ASTM E 1332, as follows.

1. Outdoor-Indoor Transmission Class: Minimum 30.

H. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes:

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 MANUFACTURERS

A. Basis-of-Design: Kawneer 500 Entrance.

2.3 ENTRANCE DOOR SYSTEMS

A. Entrance Doors: Manufacturer's standard glazed entrance doors for manual-swing operation.

1. Door Construction: 1-3/4-inch (44.5-mm) overall thickness, with minimum 0.125-inch- (3.2-mm-) thick, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deeply penetrated and fillet welded or that incorporate concealed tie rods.

    a. Thermal Construction: High-performance plastic connectors separate aluminum members exposed to the exterior from members exposed to the interior.

2. Door Design: Wide stile; 5-inch (127-mm) nominal width.
3. Glazing Stops and Gaskets: Square, snap-on, extruded-aluminum stops and preformed gaskets.

    a. Provide nonremovable glazing stops on outside of door.

B. Framing Members: Manufacturer's standard extruded aluminum, minimum 0.125 inch (3.2 mm) thick and reinforced as required to support imposed loads.

1. Nominal Size: As indicated on Drawings.

C. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.

D. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

E. Materials:

1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

    a. Sheet and Plate: ASTM B 209 (ASTM B 209M).
    b. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).
    c. Extruded Structural Pipe and Tubes: ASTM B 429/B 429M.
    d. Structural Profiles: ASTM B 308/B 308M.

2.4 ENTRANCE DOOR HARDWARE

A. Entrance Door Hardware: Hardware not specified in this Section is specified in Section 087100 "Door Hardware."

B. General: Provide entrance door hardware and coordinate door and frame prep with Section 087100 Door Hardware for each entrance door to comply with requirements in this Section.

1. Entrance Door Hardware Sets: Provide door manufacturer’s standard hardware quantity, item, size, finish or color indicated.

2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
3. Opening-Force Requirements:

    a. Egress Doors: Not more than 15 lbf (67 N) to release the latch and not more than 30 lbf (133 N)to set the door in motion.
    b. Accessible Interior Doors: Not more than 5 lbf (22.2 N) to fully open door.

C. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of entrance door hardware are indicated in this section.

D. Continuous-Gear Hinges: Manufacturer's standard with stainless-steel bearings between knuckles, fabricated to full height of door and frame.

E. Cylinders: As specified in Section 087100 "Door Hardware."

F. Weather Stripping: Manufacturer's standard replaceable components.

1. Compression Type: Made of ASTM D 2000, molded neoprene, or ASTM D 2287, molded PVC.
2. Sliding Type: AAMA 701/702, made of wool, polypropylene, or nylon woven pile with nylon-fabric or aluminum-strip backing.

G. Weather Sweeps: Manufacturer's standard exterior-door bottom sweep with concealed fasteners on mounting strip.

H. Thresholds: BHMA A156.21, raised thresholds beveled with a slope of not more than 1:2, with maximum height of 1/2 inch (12.7 mm). Omit at interior doors.

2.5 GLAZING

A. Glazing: Comply with Section 088000 "Glazing."

B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

C. Glazing Sealants: As recommended by manufacturer.

D. Sealants used inside the weatherproofing system shall have a VOC content of 250 g/L.

2.6 ACCESSORIES

A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
2. Reinforce members as required to receive fastener threads.
3. Use exposed fasteners with countersunk Phillips screw heads, finished to match framing system, fabricated from 300 series stainless steel.

B. Anchors: Three-way adjustable anchors with minimum adjustment of 1 inch (25.4 mm) that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123/A 123M or ASTM A 153/A 153M requirements.

C. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos, formulated for 30-mil (0.762-mm) thickness per coat.

2.7 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:

1. Profiles that are sharp, straight, and free of defects or deformations.
2. Accurately fitted joints with ends coped or mitered.
3. Physical and thermal isolation of glazing from framing members.
4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
5. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

D. Entrance Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.

E. Entrance Doors: Reinforce doors as required for installing entrance door hardware.

1. At pairs of exterior doors, provide sliding-type weather stripping retained in adjustable strip and mortised into door edge.
2. At exterior doors, provide weather sweeps applied to door bottoms.

F. Entrance Door Hardware Installation: Factory install entrance door hardware to the greatest extent possible. Cut, drill, and tap for factory-installed entrance door hardware before applying finishes.

G. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.8 ALUMINUM FINISHES

A. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Color and Gloss: Match Architect's sample.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare surfaces that are in contact with structural sealant according to sealant manufacturer's written instructions to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.

3.3 INSTALLATION

A. General:

1. Comply with manufacturer's written instructions.
2. Do not install damaged components.
3. Fit joints to produce hairline joints free of burrs and distortion.
4. Rigidly secure nonmovement joints.
5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
6. Seal perimeter and other joints watertight unless otherwise indicated.

B. Metal Protection:

1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or installing nonconductive spacers.

2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Set continuous sill members and flashing in full sealant bed as specified in Section 079200 "Joint Sealants" to produce weathertight installation.

D. Install components plumb and true in alignment with established lines and grades.

E. Install glazing as specified in Section 088000 "Glazing."

F. Entrance Doors: Install doors to produce smooth operation and tight fit at contact points.

1. Exterior Doors: Install to produce weathertight enclosure and tight fit at weather stripping.
2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware according to entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Field Quality-Control Testing: Perform the following test on aluminum-framed entrances.

1. Water-Spray Test: Before installation of interior finishes has begun, areas designated by Architect shall be tested according to AAMA 501.2 and shall not evidence water penetration.

C. Aluminum-framed entrances will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 MAINTENANCE SERVICE

A. Entrance Door Hardware:

1. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of entrance door hardware.
2. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of entrance door hardware Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper entrance door hardware operation at rated speed and capacity. Use parts

and supplies that are the same as those used in the manufacture and installation of original equipment.

END OF SECTION 084213

SECTION 084413 - GLAZED ALUMINUM CURTAIN WALLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes glazed aluminum curtain walls.

B. Related Requirements:

1. Section 088000 “Glazing” for insulating glass requirements.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. LEED Submittals:

1. Product Data for Indoor Environmental Quality Credit: Low-Emitting Materials: For glazing sealants used inside the weatherproofing system, documentation including printed statement of VOC content that meets VOC content limits given in Low-Emitting Material in Section 018113.13.

C. Shop Drawings: For glazed aluminum curtain walls. Include plans, elevations, sections, full-size details, and attachments to other work.

1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
2. Include full-size isometric details of each vertical-to-horizontal intersection of glazed aluminum curtain walls, showing the following:

a. Joinery, including concealed welds.
b. Anchorage.
c. Expansion provisions.
d. Glazing.
e. Flashing and drainage.

3. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

D. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.

E. Delegated-Design Submittal: For glazed aluminum curtain walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and field testing agency.

B. Energy Performance Certificates: For glazed aluminum curtain walls, accessories, and components from manufacturer.

1. Basis for Certification: NFRC-certified energy performance values for each glazed aluminum curtain wall.

C. Product Test Reports: For glazed aluminum curtain walls, for tests performed by a qualified testing agency.

D. Quality-Control Program: Developed specifically for Project, including fabrication and installation, according to recommendations in ASTM C 1401. Include periodic quality-control reports.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranties: For special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For glazed aluminum curtain walls to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Testing Agency Qualifications: Qualified according to ASTM E699 for testing indicated.

C. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.

1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.

1.8 MOCKUPS

A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockup of typical wall area as shown on Drawings.
2. Testing shall be performed on mockups according to requirements in "Field Quality Control" Article.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 WARRANTY

A. Special Assembly Warranty: Manufacturer agrees to repair or replace components of glazed aluminum curtain wall that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including, but not limited to, excessive deflection.
b. Noise or vibration created by wind and thermal and structural movements.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
d. Water penetration through fixed glazing and framing areas.
e. Failure of operating components.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design glazed aluminum curtain walls.

B. General Performance: Comply with performance requirements specified, as determined by testing of glazed aluminum curtain walls representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1. Glazed aluminum curtain walls shall withstand movements of supporting structure including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.
2. Failure also includes the following:

a. Thermal stresses transferring to building structure.
b. Glass breakage.
c. Noise or vibration created by wind and thermal and structural movements.
d. Loosening or weakening of fasteners, attachments, and other components.
e. Failure of operating units.

C. Structural Loads:

1. Wind Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.
3. Seismic Loads: As indicated on Drawings.

D. Deflection of Framing Members: At design wind pressure, as follows:

1. Deflection Normal to Wall Plane: Limited to edge of glass in a direction perpendicular to glass plane not exceeding 1/175 of the glass edge length for

each individual glazing lite or an amount that restricts edge deflection of individual glazing lites to 3/4 inch (19.1 mm), whichever is less.

2. Deflection Parallel to Glazing Plane: Limited to [1/360 of clear span or 1/8 inch (3.2 mm), whichever is smaller.

3. Cantilever Deflection: Where framing members overhang an anchor point, as follows:

   a. Perpendicular to Plane of Wall: No greater than 1/240 of clear span plus 1/4-inch (6. 35-mm) for spans greater than 11 feet 8-1/4 inches (3.6 m) or 1/175 times span, for spans less than 11 feet 8-1/4 inches (3.6 m).

E. Structural: Test according to ASTM E 330 as follows:

1. When tested at positive and negative wind-load design pressures, assemblies do not evidence deflection exceeding specified limits.
2. When tested at 150 percent of positive and negative wind-load design pressures, assemblies, including anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.
3. Test Durations: As required by design wind velocity, but not less than 10 seconds.

F. Air Infiltration: Test according to ASTM E 283 for infiltration as follows:

1. Fixed Framing and Glass Area:

   a. Maximum air leakage of 0.06 cfm/sq. ft. (0.30 L/s per sq. m) at a static-air-pressure differential of 6.24 lbf/sq. ft. (300 Pa).

G. Water Penetration under Static Pressure: Test according to ASTM E 331 as follows:

1. No evidence of water penetration through fixed glazing and framing areas when tested according to a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 10 lbf/sq. ft. (480 Pa).

H. Water Penetration under Dynamic Pressure: Test according to AAMA 501.1 as follows:

1. No evidence of water penetration through fixed glazing and framing areas when tested at dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 10 lbf/sq. ft. (480 Pa).
2. Maximum Water Leakage: No uncontrolled water penetrating assemblies or water appearing on assemblies' normally exposed interior surfaces from sources other than condensation. Water leakage does not include water controlled by flashing and gutters, or water that is drained to exterior.

I. Interstory Drift: Accommodate design displacement of adjacent stories indicated.

1. Design Displacement: 3/16 inches.

2. Test Performance: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.4 at design displacement.

J. Seismic Performance: Glazed aluminum curtain walls shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Seismic Drift Causing Glass Fallout: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.6 at design displacement.
2. Vertical Interstory Movement: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.7 at design displacement.

K. Energy Performance: Certify and label energy performance according to NFRC as follows:

1. Thermal Transmittance (U-factor): Fixed glazing and framing areas shall have U-factor of not more than 0.20 Btu/sq. ft. x h x deg F as determined according to NFRC 100.
2. Solar Heat Gain Coefficient: Fixed glazing and framing areas shall have a solar heat gain coefficient of no greater than 0.24 as determined according to NFRC 200.
3. Condensation Resistance: Fixed glazing and framing areas shall have an NFRC-certified condensation resistance rating of no less than 55 as determined according to AAMA 1503..

L. Noise Reduction: Test according to ASTM E 90, with ratings determined by ASTM E 1332, as follows:

1. Outdoor-Indoor Transmission Class: Minimum 34.

M. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes:

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
2. Thermal Cycling: No buckling; stress on glass; sealant failure; excess stress on framing, anchors, and fasteners; or reduction of performance when tested according to AAMA 501.5.

a. High Exterior Ambient-Air Temperature: That which produces an exterior metal-surface temperature of 180 deg F (82 deg C).
b. Low Exterior Ambient-Air Temperature: 0 deg F (minus 18 deg C).

2.2 MANUFACTURERS

A. Basis-of-Design: Kawneer 1600.

B. Source Limitations: Obtain all components of curtain wall system, including framing spandrel panels, entrances, and accessories, from single manufacturer.

2.3 FRAMING

A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.

1. Construction: Thermally broken.
2. Glazing System: Retained mechanically with gaskets on four sides.
3. Glazing Plane: Front.
4. Finish: Clear anodic finish.
5. Fabrication Method: Either factory- or field-fabricated system.

B. Pressure Caps: Manufacturer's standard aluminum components that mechanically retain glazing.

1. Include snap-on aluminum trim that conceals fasteners.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

D. Materials:

1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

a. Sheet and Plate: ASTM B 209 (ASTM B 209M).
b. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).
c. Extruded Structural Pipe and Tubes: ASTM B 429/B 429M.
d. Structural Profiles: ASTM B 308/B 308M.

2. Steel Reinforcement: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM, and prepare surfaces according to applicable SSPC standard.

a. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
b. Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.
c. Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.

2.4 INSULATED SPANDREL PANELS

A. Insulated Spandrel Panels: Comply with Section 074213.19 "Insulated Metal Wall Panels."

B. Insulated Spandrel Panels: Laminated, metal-faced flat panels with no deviations in plane exceeding 0.8 percent of panel dimension in width or length.

1. Overall Panel Thickness: As indicated.
2. Exterior Skin: Aluminum.

a. Thickness: Manufacturer's standard for finish and texture indicated.
b. Finish: Match framing system.
c. Texture: Smooth.
d. Backing Sheet: 0.125-inch- (3.2-mm-) thick, corrugated, high-density polyethylene.

3. Interior Skin: Aluminum.

a. Thickness: Manufacturer's standard for finish and texture indicated.
b. Finish: Matching curtain-wall framing.
c. Texture: Smooth.
d. Backing Sheet: 0.125-inch- (3.2-mm-) thick, corrugated, high-density polyethylene.

4. Thermal Insulation Core: Manufacturer's standard rigid, closed-cell, polyisocyanurate board.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 450 or less.

2.5 ENTRANCES

A. Entrances: Comply with Section 084213 "Aluminum-Framed Entrances."

2.6 GLAZING

A. Glazing: Comply with Section 088000 "Glazing."

B. Framing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

C. Framing Sealants: As recommended by manufacturer.

D. Sealants used inside the weatherproofing system shall have a VOC content of 250 g/L or less.

2.7 ACCESSORIES

A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
2. Reinforce members as required to receive fastener threads.

B. Anchors: Three-way adjustable anchors with minimum adjustment of 1 inch (25.4 mm) that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123/A 123M or ASTM A 153/A 153M requirements.

C. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials.

D. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos, formulated for 30-mil (0.762-mm) thickness per coat.

1. Protect dissimilar metals which are in contact with each other from galvanic corrosion.
2. Apply a heavy brush coat of bituminous paint to carbon steel placed in aluminum mullions.
3. Apply a heavy brush coat of alkali resistant bituminous paint to aluminum in contact with concrete.

2.8 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:

1. Profiles that are sharp, straight, and free of defects or deformations.
2. Accurately fitted joints with ends coped or mitered.
3. Physical and thermal isolation of glazing from framing members.
4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
5. Provisions for field replacement of glazing from exterior.

6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.
7. Components curved to indicated radii.

D. Fabricate components to resist water penetration as follows:

1. Internal guttering system or other means to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.

E. Curtain-Wall Framing: Fabricate components for assembly using shear-block system.

F. Factory-Assembled Frame Units:

1. Rigidly secure nonmovement joints.
2. Prepare surfaces that are in contact structural sealant according to sealant manufacturer's written instructions to ensure compatibility and adhesion.
3. Preparation includes, but is not limited to, cleaning and priming surfaces.
4. Seal joints watertight unless otherwise indicated.
5. Install glazing to comply with requirements in Section 088000 "Glazing."

G. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.9 ALUMINUM FINISHES

A. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Color and Gloss: Match Architect's sample.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:

1. Comply with manufacturer's written instructions.
2. Do not install damaged components.
3. Fit joints to produce hairline joints free of burrs and distortion.
4. Rigidly secure nonmovement joints.
5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
6. Where welding is required, weld components in concealed locations to minimize distortion or discoloration of finish. Protect glazing surfaces from welding.
7. Seal joints watertight unless otherwise indicated.

B. Metal Protection:

1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with primer, applying sealant or tape, or installing nonconductive spacers as recommended by manufacturer for this purpose.
2. Where aluminum is in contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.

D. Install components plumb and true in alignment with established lines and grades.

E. Install glazing as specified in Section 088000 "Glazing."

F. Install weatherseal sealant according to Section 079200 "Joint Sealants" and according to sealant manufacturer's written instructions to produce weatherproof joints. Install joint filler behind sealant as recommended by sealant manufacturer.

3.3 ERECTION TOLERANCES

A. Erection Tolerances: Install glazed aluminum curtain walls to comply with the following maximum tolerances:

1. Plumb: 1/8 inch in 10 feet (3.2 mm in 3 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
2. Level: 1/8 inch in 20 feet (3.2 mm in 6 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
3. Alignment:

    a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch (12.7 mm) wide, limit offset from true alignment to 1/16 inch (1.6 mm).
    b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch (12.7 to 25.4 mm) wide, limit offset from true alignment to 1/8 inch (3.2 mm).

c. Where surfaces are separated by reveal or protruding element of 1 inch (25.4 mm) wide or more, limit offset from true alignment to 1/4 inch (6 mm).

4. Location: Limit variation from plane to 1/8 inch in 12 feet (3.2 mm in 3.6 m); 1/2 inch (12.7 mm) over total length.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Test Area: Perform tests on one bay at least 30 feet (9.1 m), by one story on mockups.

C. Field Quality-Control Testing: Perform the following test on mockups.

1. Water-Spray Test: Before installation of interior finishes has begun, areas designated by Architect shall be tested according to AAMA 501.2 and shall not evidence water penetration.

a. Perform a minimum of two tests in areas as directed by Architect.

2. Air Infiltration: ASTM E 783 at 1.5 times the rate specified for laboratory testing in "Performance Requirements" Article but not more than 0.09 cfm/sq. ft. (0.45 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft. (75 Pa).

a. Perform a minimum of two tests in areas as directed by Architect.

3. Water Penetration: ASTM E 1105 at a minimum uniform static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft. (300 Pa), and shall not evidence water penetration.

D. Glazed aluminum curtain walls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. Repair or remove work where test results and inspections indicate that it does not comply with specified requirements.

G. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

END OF SECTION 084413

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes:

1. Mechanical and electrified door hardware for:

    a. Swinging doors.

2. Electronic access control system components, including:

    a. Electronic access control devices.

3. Field verification, preparation and modification of existing doors and frames to receive new door hardware.
4. The intent of the hardware specification is to specify the hardware for interior and exterior doors, and to establish a type, continuity, and standard of quality. However, it is the door hardware supplier’s responsibility to thoroughly review existing conditions, schedules, specifications, drawings, and other Contract Documents to verify the suitability of the hardware specified.

B. Related Sections:

1. Division 01 Section “Alternates” for alternates affecting this section.
2. Division 07 Section “Joint Sealants” for sealant requirements applicable to threshold installation specified in this section.
3. Division 09 sections for touchup, finishing or refinishing of existing openings modified by this section.
4. Division 26 sections for connections to electrical power system and for low-voltage wiring.
5. Division 28 sections for coordination with other components of electronic access control system.

1.03 REFERENCES

A. UL - Underwriters Laboratories

1. UL 10B - Fire Test of Door Assemblies
2. UL 10C - Positive Pressure Test of Fire Door Assemblies

3. UL 1784 - Air Leakage Tests of Door Assemblies
4. UL 305 - Panic Hardware

B. DHI - Door and Hardware Institute

1. Sequence and Format for the Hardware Schedule
2. Recommended Locations for Builders Hardware
3. Key Systems and Nomenclature

C. ANSI - American National Standards Institute

1. ANSI/BHMA A156.1 - A156.29, and ANSI/BHMA A156.31 - Standards for Hardware and Specialties

1.04 SUBMITTALS

A. General:

1. Submit in accordance with Conditions of Contract and Division 01 requirements.
2. Highlight, encircle, or otherwise specifically identify on submittals deviations from Contract Documents, issues of incompatibility or other issues which may detrimentally affect the Work.
3. Prior to forwarding submittal, comply with procedures for verifying existing door and frame compatibility for new hardware, as specified in PART 3, “EXAMINATION” article, herein.

B. Action Submittals:

1. Product Data: Technical product data for each item of door hardware, installation instructions, maintenance of operating parts and finish, and other information necessary to show compliance with requirements.
2. Riser and Wiring Diagrams: After final approval of hardware schedule, submit details of electrified door hardware, indicating:

a. Wiring Diagrams: For power, signal, and control wiring and including:

1) Details of interface of electrified door hardware and building safety and security systems.
2) Schematic diagram of systems that interface with electrified door hardware.
3) Point-to-point wiring.
4) Risers.

3. Samples for Verification: If requested by Architect, submit production sample or sample installations of each type of exposed hardware unit in finish indicated, and tagged with full description for coordination with schedule.

a. Samples will be returned to supplier. Units that are acceptable to Architect may, after final check of operations, be incorporated into Work, within limitations of key coordination requirements.

4. Door Hardware Schedule: Submit schedule with hardware sets in vertical format as illustrated by Sequence of Format for the Hardware Schedule as published by the Door and Hardware Institute. Indicate complete designations of each item required for each door or opening, include:

    a. Door Index; include door number, heading number, and Architects hardware set number.
    b. Opening Lock Function Spreadsheet: List locking device and function for each opening.
    c. Quantity, type, style, function, size, and finish of each hardware item.
    d. Name and manufacturer of each item.
    e. Fastenings and other pertinent information.
    f. Location of each hardware set cross-referenced to indications on Drawings.
    g. Explanation of all abbreviations, symbols, and codes contained in schedule.
    h. Mounting locations for hardware.
    i. Door and frame sizes and materials.
    j. Name and phone number for local manufacturer's representative for each product.
    k. Operational Description of openings with any electrified hardware (locks, exits, electromagnetic locks, electric strikes, automatic operators, door position switches, magnetic holders or closer/holder units, and access control components). Operational description should include operational descriptions for: egress, ingress (access), and fire/smoke alarm connections.

        1) Submittal Sequence: Submit door hardware schedule concurrent with submissions of Product Data, Samples, and Shop Drawings. Coordinate submission of door hardware schedule with scheduling requirements of other work to facilitate fabrication of other work that is critical in Project construction schedule.

5. Key Schedule:

    a. After Keying Conference, provide keying schedule listing levels of keying as well as explanation of key system's function, key symbols used and door numbers controlled.
    b. Use ANSI/BHMA A156.28 “Recommended Practices for Keying Systems” as guideline for nomenclature, definitions, and approach for selecting optimal keying system.
    c. Provide 3 copies of keying schedule for review prepared and detailed in accordance with referenced DHI publication. Include schematic keying diagram and index each key to unique door designations.
    d. Index keying schedule by door number, keyset, hardware heading number, cross keying instructions, and special key stamping instructions.
    e. Provide one complete bitting list of key cuts and one key system schematic illustrating system usage and expansion.

1) Forward bitting list, key cuts and key system schematic directly to Owner, by means as directed by Owner.

f. Prepare key schedule by or under supervision of supplier, detailing Owner's final keying instructions for locks.

6. Templates: After final approval of hardware schedule, provide templates for doors, frames and other work specified to be factory or shop prepared for door hardware installation.

C. Informational Submittals:

1. Qualification Data: For Supplier, Installer and Architectural Hardware Consultant.
2. Product data for electrified door hardware:

a. Certify that door hardware approved for use on types and sizes of labeled fire-rated doors complies with listed fire-rated door assemblies.

3. Certificates of Compliance:

a. UL listings for fire-rated hardware and installation instructions if requested by Architect or Authority Having Jurisdiction.
b. Installer Training Meeting Certification: Letter of compliance, signed by Contractor, attesting to completion of installer training meeting specified in "QUALITY ASSURANCE" article, herein.
c. Electrified Hardware Coordination Conference Certification: Letter of compliance, signed by Contractor, attesting to completion of electrified hardware coordination conference, specified in "QUALITY ASSURANCE" article, herein.

4. Product Test Reports: For compliance with accessibility requirements, based on evaluation of comprehensive test performed by manufacturer and witnessed by qualified testing agency, for door hardware on doors located in accessible routes.
5. Warranty: Special warranty specified in this Section.

D. Fire Door Assembly Inspection and Testing:

1. Submit a written report of the results of functional testing and inspection for fire door assemblies, in compliance with NFPA 80-2007 requirements. Written report shall be provided to the Owner to be made available to the Authority Having Jurisdiction (AHJ). Report shall include the door number for each fire door assembly, door location, door and frame material, fire rating, and summary of deficiencies.

E. Closeout Submittals:

1. Operations and Maintenance Data: Provide in accordance with Division 01 and include:

a. Complete information on care, maintenance, and adjustment; data on repair and replacement parts, and information on preservation of finishes.

b. Catalog pages for each product.
c. Factory order acknowledgement numbers (for warranty and service)
d. Name, address, and phone number of local representative for each manufacturer.
e. Parts list for each product.
f. Final approved hardware schedule, edited to reflect conditions as-installed.
g. Final keying schedule
h. Copies of floor plans with keying nomenclature
i. As-installed wiring diagrams for each opening connected to power, both low voltage and 110 volts.
j. Copy of warranties including appropriate reference numbers for manufacturers to identify project.

1.05 QUALITY ASSURANCE

A. Supplier Qualifications and Responsibilities: Recognized architectural hardware supplier with record of successful in-service performance for supplying door hardware similar in quantity, type, and quality to that indicated for this Project and that provides certified Architectural Hardware Consultant (AHC) available to Owner, Architect, and Contractor, at reasonable times during the Work for consultation.

1. Warehousing Facilities: In Project's vicinity.
2. Scheduling Responsibility: Preparation of door hardware and keying schedules.
3. Engineering Responsibility: Preparation of data for electrified door hardware, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
4. Coordination Responsibility: Assist in coordinating installation of electronic security hardware with Architect and electrical engineers and provide installation and technical data to Architect and other related subcontractors.

    a. Upon completion of electronic security hardware installation, inspect and verify that all components are working properly.

B. Installer Qualifications: Qualified tradesmen, skilled in application of commercial grade hardware with record of successful in-service performance for installing door hardware similar in quantity, type, and quality to that indicated for this Project.

C. Architectural Hardware Consultant Qualifications: Person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and meets these requirements:

1. For door hardware, DHI-certified, Architectural Hardware Consultant (AHC).
2. Can provide installation and technical data to Architect and other related subcontractors.
3. Can inspect and verify components are in working order upon completion of installation.

4. Capable of producing wiring diagrams.
5. Capable of coordinating installation of electrified hardware with Architect and electrical engineers.
6. AHC shall supervise installation of all hardware, observe, direct the initial installations, review the work in progress periodically, inspect the final installations, direct necessary adjustments and corrections for a complete and functional installation.

D. Single Source Responsibility: Obtain each type of door hardware from single manufacturer.

1. Provide electrified door hardware from same manufacturer as mechanical door hardware, unless otherwise indicated.

E. Fire-Rated Door Openings: Provide door hardware for fire-rated openings that complies with NFPA 80 and requirements of authorities having jurisdiction. Provide only items of door hardware that are listed products tested by Underwriters Laboratories, Intertek Testing Services, or other testing and inspecting organizations acceptable to authorities having jurisdiction for use on types and sizes of doors indicated, based on testing at positive pressure and according to NFPA 252 or UL 10C and in compliance with requirements of fire-rated door and door frame labels.

F. Smoke- and Draft-Control Door Assemblies: Where smoke- and draft-control door assemblies are required, provide door hardware that meets requirements of assemblies tested according to UL 1784 and installed in compliance with NFPA 105.

1. Air Leakage Rate: Maximum air leakage of 0.3 cfm/sq. ft. (3 cu. M per minute/sq. m) at tested pressure differential of 0.3-inch wg (75 Pa) of water.

G. Electrified Door Hardware: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction.

H. Means of Egress Doors: Latches do not require more than 15 lbf (67 N) to release latch. Locks do not require use of key, tool, or special knowledge for operation.

I. Accessibility Requirements: For door hardware on doors in an accessible route, comply with governing accessibility regulations cited in “REFERENCES” article, herein.

1. Provide operating devices that do not require tight grasping, pinching, or twisting of wrist and that operate with force of not more than 5 lbf (22.2 N).
2. Maximum opening-force requirements:

a. Interior, Non-Fire-Rated Hinged Doors: 5 lbf (22.2 N) applied perpendicular to door.
b. Sliding or Folding Doors: 5 lbf (22.2 N) applied parallel to door at latch.
c. Fire Doors: Minimum opening force allowable by authorities having jurisdiction.

3. Bevel raised thresholds with slope of not more than 1:2. Provide thresholds not more than ½ inch (13 mm) high.
4. Adjust door closer sweep periods so that, from open position of 70 degrees, door will take at least 3 seconds to move to 3 inches (75 mm) from latch, measured to leading edge of door.

J. Keying Conference

1. Incorporate keying conference decisions into final keying schedule after reviewing door hardware keying system including:

   a. Function of building, flow of traffic, purpose of each area, degree of security required, and plans for future expansion.
   b. Preliminary key system schematic diagram.
   c. Requirements for key control system.
   d. Requirements for access control.
   e. Address for delivery of keys.

K. Pre-installation Conference

1. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
2. Inspect and discuss preparatory work performed by other trades.
3. Inspect and discuss electrical roughing-in for electrified door hardware.
4. Review sequence of operation for each type of electrified door hardware.
5. Review required testing, inspecting, and certifying procedures.
6. AHC shall lead these discussions.

L. Coordination Conferences:

1. Installation Coordination Conference: Prior to hardware installation, schedule and hold meeting to review questions or concerns related to proper installation and adjustment of door hardware.
2. Electrified Hardware Coordination Conference: Prior to ordering electrified hardware, schedule and hold meeting to coordinate door hardware with security, electrical, doors and frames, and other related suppliers.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Inventory door hardware on receipt and provide secure lock-up for hardware delivered to Project site.

B. Tag each item or package separately with identification coordinated with final door hardware schedule, and include installation instructions, templates, and necessary fasteners with each item or package.

1. Deliver each article of hardware in manufacturer’s original packaging.

C. Project Conditions:

1. Maintain manufacturer-recommended environmental conditions throughout storage and installation periods.
2. Provide secure lock-up for door hardware delivered to Project. Control handling and installation of hardware items so that completion of Work will not be delayed by hardware losses both before and after installation.

D. Protection and Damage:

1. Promptly replace products damaged during shipping.
2. Handle hardware in manner to avoid damage, marring, or scratching. Correct, replace or repair products damaged during Work.
3. Protect products against malfunction due to paint, solvent, cleanser, or any chemical agent.

E. Deliver keys to manufacturer of key control system for subsequent delivery to Owner.

F. Deliver keys and permanent cores to Owner by registered mail or overnight package service.

1.07 COORDINATION

A. Coordinate layout and installation of floor-recessed door hardware with floor construction. Cast anchoring inserts into concrete.

B. Installation Templates: Distribute for doors, frames, and other work specified to be factory or shop prepared. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

C. Security: Coordinate installation of door hardware, keying, and access control with Owner's security consultant.

D. Electrical System Roughing-In: Coordinate layout and installation of electrified door hardware with connections to power supplies and building safety and security systems.

E. Existing Openings: Where existing doors, frames and/or hardware are to remain, field verify existing functions, conditions and preparations and coordinate to suit opening conditions and to provide proper door operation.

1.08 WARRANTY

A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Beginning from date of Substantial Completion, for durations indicated.

    a. Closers:

        1) Mechanical: 10 years.
        2) Electrified: 2 years.

    b. Automatic Operators: 2 years.
    c. Exit Devices:

        1) Mechanical: 3 years.
        2) Electrified: 1 year.

    d. Locksets:

        1) Mechanical: 3 years.
        2) Electrified: 1 year.

    e. Continuous Hinges: Lifetime warranty.
    f. Key Blanks: Lifetime

2. Warranty does not cover damage or faulty operation due to improper installation, improper use or abuse.

1.09 MAINTENANCE

A. Maintenance Tools: Furnish complete set of special tools required for maintenance and adjustment of hardware, including changing of cylinders.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The Owner requires use of certain products for their unique characteristics and project suitability to insure continuity of existing and future performance and maintenance standards. After investigating available product offerings, the Awarding Authority has elected to prepare proprietary specifications. These products are specified with the notation: “No Substitute.”

    1. Where “No Substitute” is noted, submittals and substitution requests for other products will not be considered.

B. Approval of manufacturers and/or products other than those listed as “Scheduled Manufacturer” or “Acceptable Manufacturers” in the individual article for the product category shall be in accordance with QUALITY ASSURANCE article, herein.

C. Approval of products from manufacturers indicated in “Acceptable Manufacturers” is contingent upon those products providing all functions and features and meeting all requirements of scheduled manufacturer’s product.

D. Where specified hardware is not adaptable to finished shape or size of members requiring hardware, furnish suitable types having same operation and quality as type specified, subject to Architect's approval.

E. Hand of Door: Drawings show direction of slide, swing, or hand of each door leaf. Furnish each item of hardware for proper installation and operation of door movement as shown.

2.02 MATERIALS

A. Fasteners

1. Provide hardware manufactured to conform to published templates, generally prepared for machine screw installation.
2. Furnish screws for installation with each hardware item. Finish exposed (exposed under any condition) screws to match hardware finish, or, if exposed in surfaces of other work, to match finish of this other work including prepared for paint surfaces to receive painted finish.
3. Provide concealed fasteners for hardware units exposed when door is closed except when no standard units of type specified are available with concealed fasteners. Do not use thru-bolts for installation where bolt head or nut on opposite face is exposed in other work unless thru-bolts are required to fasten hardware securely. Review door specification and advise Architect if thru-bolts are required.
4. Install hardware with fasteners provided by hardware manufacturer.

B. Modification and Preparation of Existing Doors: Where existing door hardware is indicated to be removed and reinstalled.

1. Provide necessary fillers, Dutchmen, reinforcements, and fasteners, compatible with existing materials, as required for mounting new opening hardware and to cover existing door and frame preparations.
2. Use materials which match materials of adjacent modified areas.
3. When modifying existing fire-rated openings, provide materials permitted by NFPA 80 as required to maintain fire-rating.

C. Provide screws, bolts, expansion shields, drop plates and other devices necessary for hardware installation.

1. Where fasteners are exposed to view: Finish to match adjacent door hardware material.

D. Cable and Connectors: Hardwired Electronic Access Control Lockset and Exit Device Trim:

1. Data: 24AWG, 4 conductor shielded, Belden 9843, 9841 or comparable.
2. DC Power: 18 AWG, 2 conductor, Belden 8760 or comparable.
3. Provide type of data and DC power cabling required by access control device manufacturer for this installation.
4. Provide each item of electrified hardware and wire harnesses with sufficient number and wire gauge with standardized Molex plug connectors to accommodate electric function of specified hardware. Provide Molex connectors that plug directly into connectors from harnesses, electric locking and power transfer devices. Provide through-door wire harness for each electrified locking device installed in a door and wire harness for each electrified hinge, electrified continuous hinge, electrified pivot, and electric power transfer for connection to power supplies.

2.03 HINGES

A. Manufacturers and Products:

1. Scheduled Manufacturer and Product: Ives 5BB series.
2. Acceptable Manufacturers and Products: Hager BB series, McKinney TA/T4A series.

B. Requirements:

1. Provide hinges conforming to ANSI/BHMA A156.1.
2. 1-3/4 inch (44 mm) thick doors, up to and including 36 inches (914 mm) wide:

    a. Exterior: Standard weight, bronze or stainless steel, 4-1/2 inches (114 mm) high
    b. Interior: Standard weight, steel, 4-1/2 inches (114 mm) high

3. 1-3/4 inch (44 mm) thick doors over 36 inches (914 mm) wide:

    a. Exterior: Heavy weight, bronze/stainless steel, 5 inches (127 mm) high
    b. Interior: Heavy weight, steel, 5 inches (127 mm) high

4. 2 inches or thicker doors:

    a. Exterior: Heavy weight, bronze or stainless steel, 5 inches (127 mm) high
    b. Interior: Heavy weight, steel, 5 inches (127 mm) high

5. Provide three hinges per door leaf for doors 90 inches (2286 mm) or less in height, and one additional hinge for each 30 inches (762 mm) of additional door height.
6. Where new hinges are specified for existing doors or existing frames, provide new hinges of identical size to hinge preparation present in existing door or existing frame.
7. Hinge Pins: Except as otherwise indicated, provide hinge pins as follows:

    a. Steel Hinges: Steel pins
    b. Non-Ferrous Hinges: Stainless steel pins

c. Out-Swinging Exterior Doors: Non-removable pins
d. Out-Swinging Interior Lockable Doors: Non-removable pins
e. Interior Non-lockable Doors: Non-rising pins

8. Width of hinges: 4-1/2 inches (114 mm) at 1-3/4 inch (44 mm) thick doors, and 5 inches (127 mm) at 2 inches (51 mm) or thicker doors. Adjust hinge width as required for door, frame, and wall conditions to allow proper degree of opening.
9. Doors 36 inches (914 mm) wide or less, furnish hinges 4-1/2 inches (114 mm) high; doors greater than 36 inches (914 mm) wide, furnish hinges 5 inches (127 mm) high, heavy weight or standard weight as specified.
10. Provide hinges with electrified options as scheduled in the hardware sets. Provide with sufficient number and wire gage to accommodate electric function of specified hardware. Locate electric hinge at second hinge from bottom or nearest to electrified locking component.
11. Provide mortar guard for each electrified hinge specified.
12. Provide spring hinges where specified. Provide two spring hinges and one bearing hinge per door leaf for doors 90 inches (2286 mm) or less in height. Provide one additional bearing hinge for each 30 inches (762 mm) of additional door height.

2.04 CONTINUOUS HINGES

A. Aluminum Geared

1. Manufacturers:

a. Scheduled Manufacturer: Ives.
b. Acceptable Manufacturers: McKinney, Select.

2. Requirements:

a. Provide aluminum geared continuous hinges conforming to ANSI/BHMA A156.26, Grade 1.
b. Provide aluminum geared continuous hinges, where specified in the hardware sets, fabricated from 6063-T6 aluminum.
c. Provide split nylon bearings at each hinge knuckle for quiet, smooth, self-lubricating operation.
d. Provide hinges capable of supporting door weights up to 450 pounds, and successfully tested for 1,500,000 cycles.
e. On fire-rated doors, provide aluminum geared continuous hinges that are classified for use on rated doors by testing agency acceptable to authority having jurisdiction.
f. Provide aluminum geared continuous hinges with electrified option scheduled in the hardware sets. Provide with sufficient number and wire gage to accommodate electric function of specified hardware.
g. Install hinges with fasteners supplied by manufacturer.
h. Provide hinges 1 inch (25 mm) shorter in length than nominal height of door, unless otherwise noted or door details require shorter length and with symmetrical hole pattern.

2.05 ELECTRIC POWER TRANSFER

A. Manufacturers:

a. Scheduled Manufacturer: Von Duprin EPT-10.
b. Acceptable Manufacturers: Falon, ABH.

B. Provide power transfer with electrified options as scheduled in the hardware sets. Provide with number and gage of wires sufficient to accommodate electric function of specified hardware.

C. Locate electric power transfer per manufacturer's template and UL requirements, unless interference with operation of door or other hardware items.

2.06 FLUSH BOLTS

A. Manufacturers:

1. Scheduled Manufacturer: Ives.
2. Acceptable Manufacturers: Burns, Rockwood.

B. Requirements:

1. Provide automatic, constant latching, and manual flush bolts with forged bronze or stainless-steel face plates, extruded brass levers, and with wrought brass guides and strikes. Provide 12 inch (305 mm) steel or brass rods at doors up to 90 inches (2286 mm) in height. For doors over 90 inches (2286 mm) in height increase top rods by 6 inches (152 mm) for each additional 6 inches (152 mm) of door height. Provide dust-proof strikes at each bottom flush bolt.

2.07 CYLINDRICAL LOCKS – GRADE 1

A. Manufacturers and Products:

1. Scheduled Manufacturer and Product: Schlage ND Series.
2. No substitutions.

B. Requirements:

1. Provide cylindrical locks conforming to ANSI/BHMA A156.2 Series 4000, Grade 1. Cylinders: Refer to "KEYING" article, herein.
2. Provide locksets able to withstand 3100 inch pounds of torque applied to locked outside lever without gaining access per ANSI/BHMA A156.2 Abusive Locked Lever Torque Test and cycle tested to 3 million cycles per ANSI/BHMA A156.2 Cycle Test.
3. Provide levers with vandal resistant technology for use at heavy traffic or abusive applications. Levers feature internal lock components that prevent damage

caused by excessive force from persons kicking, hitting or standing on lever to gain access.
4. Provide solid steel rotational stops to control excessive rotation of lever.
5. Provide completely refunctionable lockset that allows lock function to be changed to over twenty other common functions by swapping easily accessible parts.
6. Provide locks with standard 2-3/4 inches (70 mm) backset, unless noted otherwise, with 1/2 inch latch throw. Provide proper latch throw for UL listing at pairs.
7. Provide locksets with separate anti-rotation thru-bolts, and no exposed screws.
8. Provide independently operating levers with two external return spring cassettes mounted under roses to prevent lever sag.
9. Provide standard ASA strikes unless extended lip strikes are necessary to protect trim.
10. Provide electrified options as scheduled in the hardware sets.
11. Lever Trim: Solid cast levers without plastic inserts, and wrought roses on both sides.

    a. Lever Design: Schlage Sparta (SPA).
    b. Tactile Warning (Knurling): Where required by authority having jurisdiction. Provide on levers on exterior (secure side) of doors serving rooms considered to be hazardous.

2.08 EXIT DEVICES

A. Manufacturers and Products:

1. Scheduled Manufacturer and Product: Von Duprin 99/33A series.
2. Acceptable Manufacturers and Products: No Substitute.

B. Requirements:

1. Provide exit devices tested to ANSI/BHMA A156.3 Grade 1 and UL listed for Panic Exit or Fire Exit Hardware.
2. Cylinders: Refer to “KEYING” article, herein.
3. Provide touchpad type exit devices, fabricated of brass, bronze, stainless steel, or aluminum, plated to standard architectural finishes to match balance of door hardware.
4. Touchpad must extend a minimum of one half of door width. No plastic inserts are allowed in touchpads.
5. Provide exit devices with deadlatching feature for security and for future addition of alarm kits and/or other electrified requirements.
6. Provide flush end caps for exit devices.
7. Provide exit devices with manufacturer’s approved strikes.
8. Provide exit devices cut to door width and height. Install exit devices at height recommended by exit device manufacturer, allowable by governing building codes, and approved by Architect.

9. Mount mechanism case flush on face of doors, or provide spacers to fill gaps behind devices. Where glass trim or molding projects off face of door, provide glass bead kits.
10. Provide cylinder or hex-key dogging as specified at non fire-rated openings.
11. Provide electrified options as scheduled.
12. Provide exit devices with optional trim designs to match other lever and pull designs used on the project.

    a. Tactile Warning (Knurling): Where required by authority having jurisdiction. Provide on levers on exterior (secure side) of doors serving rooms considered to be hazardous.

13. Provide UL labeled fire exit hardware for fire rated openings.

2.09 POWER SUPPLIES

A. Manufacturers and Products:

1. Scheduled Manufacturer and Product: Schlage/Von Duprin PS900 series.
2. Acceptable Manufacturers and Products: No Substitute.

B. Requirements:

1. Provide power supplies approved by manufacturer of supplied electrified hardware.
2. Provide appropriate quantity of power supplies necessary for proper operation of electrified locking components as recommended by manufacturer of electrified locking components with consideration for each electrified component using power supply, location of power supply, and approved wiring diagrams. Locate power supplies as directed by Architect.
3. Provide regulated and filtered 24 VDC power supply, and UL class 2 listed.
4. Provide power supplies with the following features:

    a. 12/24 VDC Output, field selectable.
    b. Class 2 Rated power limited output.
    c. Universal 120-240 VAC input.
    d. Low voltage DC, regulated and filtered.
    e. Polarized connector for distribution boards.
    f. Fused primary input.
    g. AC input and DC output monitoring circuit w/LED indicators.
    h. Cover mounted AC Input indication.
    i. Tested and certified to meet UL294.
    j. NEMA 1 enclosure.
    k. Hinged cover w/lock down screws.
    l. High voltage protective cover.

5. Provide power supply in an enclosure, complete, and requiring 120VAC to fused input.

6. Provide power supply with emergency release terminals, where specified, that allow release of all devices upon activation of fire alarm system complete with fire alarm input for initiating “no delay” exiting mode.

2.10 CYLINDERS

A. Manufacturers:

1. Scheduled Manufacturer: Best, No Substitute.

B. Requirements:

1. Provide interchangeable cylinders/cores compliant with ANSI/BHMA A156.5; latest revision; cylinder face finished to match lockset, manufacturer’s series as indicated. Refer to “KEYING” article, herein.

C. Construction Keying:

1. Replaceable Construction Cores.

a. Provide temporary construction cores replaceable by permanent cores, furnished in accordance with the following requirements.

1) 3 construction control keys
2) 12 construction change (day) keys.

b. Owner or Owner’s Representative will replace temporary construction cores with permanent cores.

D. Provide cylinders and keys for miscellaneous items specified elsewhere (i.e. access panels, mesh partition doors, etc.)

2.11 KEYING

A. Provide cylinders/cores keyed into Owner’s existing factory registered keying system.

B. Comply with guidelines in ANSI/BHMA A156.28, incorporating decisions made at keying conference.

C. Requirements:

1. Provide permanent cylinders/cores keyed by the manufacturer according to the following key system.

a. Master Keying system as directed by the Owner.

2. Forward bitting list and keys separately from cylinders, by means as directed by Owner. Failure to comply with forwarding requirements will be cause for replacement of cylinders/cores involved at no additional cost to Owner.
3. Provide keys with the following features:

    a. Material: Nickel silver
    b. Patent Protection: Keys and blanks protected by one or more utility patent(s)

4. Identification:

    a. Mark permanent cylinders/cores and keys with applicable blind code per DHI publication “Keying Systems and Nomenclature” for identification. Do not provide blind code marks with actual key cuts.
    b. Identification stamping provisions must be approved by the Architect and Owner.
    c. Stamp cylinders/cores and keys with Owner’s unique key system facility code as established by the manufacturer; key symbol and embossed or stamped with “DO NOT DUPLICATE” along with the “PATENTED” or patent number to enforce the patent protection.
    d. Failure to comply with stamping requirements will be cause for replacement of keys involved at no additional cost to Owner.
    e. Forward permanent cylinders/cores to Owner, separately from keys, by means as directed by Owner.

5. Quantity: Furnish in the following quantities.

    a. Change (Day) Keys: 3 per cylinder/core.
    b. Permanent Control Keys: 3.
    c. Master Keys: 6.

2.12 DOOR CLOSERS

A. Manufacturers and Products:

1. Scheduled Manufacturer and Product: LCN 4040XP series.
2. Acceptable Manufacturers and Products: No Substitute.

B. Requirements:

1. Provide door closers conforming to ANSI/BHMA A156.4 Grade 1 requirements by BHMA certified independent testing laboratory. ISO 9000 certify closers. Stamp units with date of manufacture code.
2. Provide door closers with fully hydraulic, full rack and pinion action with high strength cast iron cylinder, and full complement bearings at shaft.
3. Cylinder Body: 1-1/2 inch (38 mm) diameter with 3/4 inch (19 mm) diameter double heat-treated pinion journal.
4. Hydraulic Fluid: Fireproof, passing requirements of UL10C, and requiring no seasonal closer adjustment for temperatures ranging from 120 degrees F to -30 degrees F.

5. Spring Power: Continuously adjustable over full range of closer sizes, and providing reduced opening force as required by accessibility codes and standards.
6. Hydraulic Regulation: By tamper-proof, non-critical valves, with separate adjustment for latch speed, general speed, and backcheck.
7. Provide closers with solid forged steel main arms and factory assembled heavy-duty forged forearms for parallel arm closers.
8. Pressure Relief Valve (PRV) Technology: Not permitted.
9. Finish for Closer Cylinders, Arms, Adapter Plates, and Metal Covers: Powder coating finish which has been certified to exceed 100 hours salt spray testing as described in ANSI Standard A156.4 and ASTM B117, or has special rust inhibitor (SRI).
10. Provide special templates, drop plates, mounting brackets, or adapters for arms as required for details, overhead stops, and other door hardware items interfering with closer mounting.

2.13 ELECTRO-HYDRAULIC AUTOMATIC OPERATORS

A. Manufacturers and Products:

1. Scheduled Manufacturer and Product: LCN 4600 series.
2. Acceptable Manufacturers and Products: No Substitute.

B. Requirements:

1. Provide low energy automatic operator units with hydraulic closer complying with ANSI/BHMA A156.19.
2. Hydraulic Fluid: Fireproof, passing requirements of UL10C, and requiring no seasonal closer adjustment for temperatures ranging from 120 degrees F to -30 degrees F.
3. Provide units with conventional door closer opening and closing forces unless power operator motor is activated. Provide door closer assembly with adjustable spring size, back-check, and opening and closing speed adjustment valves to control door
4. Provide units with on/off switch for manual operation, motor start up delay, vestibule interface delay, electric lock delay, and door hold open delay.
5. Provide units with conventional door closer opening and closing forces unless power operator motor is activated. Provide door closer assembly with adjustable spring size, back-check valve, sweep valve, latch valve to control door.
6. Provide drop plates, brackets, or adapters for arms as required for details.
7. Provide hard-wired actuator switches for operation as specified.
8. Provide weather-resistant actuators at exterior applications.
9. Provide key switches with LED’s, recommended and approved by manufacturer of automatic operator as required for function described in operation description of hardware group below. Cylinders: Refer to “KEYING” article, herein.
10. Provide complete assemblies of controls, switches, power supplies, relays, and parts/material recommended and approved by manufacturer of automatic operator for each individual leaf. Actuators control both doors simultaneously at

pairs. Sequence operation of exterior and vestibule doors with automatic operators to allow ingress or egress through both sets of openings as directed by Architect. Locate actuators, key switches, and other controls as directed by Architect.

11. Provide units with vestibule inputs that allow sequencing operation of two units, and SPDT relay for interfacing with latching or locking devices.

2.14 DOOR TRIM

A. Manufacturers:

1. Scheduled Manufacturer: Ives.
2. Acceptable Manufacturers: Burns, Rockwood.

B. Requirements:

1. Provide push plates 4 inches (102 mm) wide by 16 inches (406 mm) high by 0.050 inch (1 mm) thick and beveled 4 edges. Where width of door stile prevents use of 4 inches (102 mm) wide plate, adjust width to fit.
2. Provide push bars of solid bar stock, diameter and length as scheduled. Provide push bars of sufficient length to span from center to center of each stile. Where required, mount back to back with pull.
3. Provide offset pulls of solid bar stock, diameter and length as scheduled. Where required, mount back to back with push bar.
4. Provide pulls of solid bar stock, diameter and length as scheduled. Where required, mount back to back with push bar.
5. Provide pull plates 4 inches (102 mm) wide by 16 inches (406 mm) high by 0.050 inch (1 mm) thick, beveled 4 edges, and prepped for pull. Where width of door stile prevents use of 4 inches (102 mm) wide plate, adjust width to fit.

2.15 PROTECTION PLATES

A. Manufacturers:

1. Scheduled Manufacturer: Ives.
2. Acceptable Manufacturers: Burns, Rockwood.

B. Requirements:

1. Provide kick plates, mop plates, and armor plates minimum of 0.050 inch (1 mm) thick, beveled four edges as scheduled. Furnish with sheet metal or wood screws, finished to match plates.
2. Sizes of plates:

    a. Kick Plates: 10 inches (254 mm) high by 1-1/2 inches (38 mm) less width of door on single doors, 1 inch (25 mm) less width of door on pairs
    b. Mop Plates: 4 inches (102 mm) high by 1-1/2 inches (38 mm) less width of door on single doors, 1 inch (25 mm) less width of door on pairs

c. Armor Plates: 36 inches (914 mm) high by 1-1/2 inches (38 mm) less width of door on single doors, 1 inch (25 mm) less width of door on pairs

2.16 OVERHEAD STOPS AND OVERHEAD STOP/HOLDERS

A. Manufacturers:

1. Scheduled Manufacturers: Glynn-Johnson.
2. Acceptable Manufacturers: Rixson, Sargent.

B. Requirements:

1. Provide heavy duty concealed mounted overhead stop or holder as specified for exterior and interior vestibule single acting doors.
2. Provide heavy duty concealed mounted overhead stop of holder as specified for double acting doors.
3. Provide heavy or medium duty and concealed or surface mounted overhead stop or holder for interior doors as specified. Provide medium duty surface mounted overhead stop for interior doors and at any door that swings more than 140 degrees before striking wall, open against equipment, casework, sidelights, and where conditions do not allow wall stop or floor stop presents tripping hazard.
4. Where overhead holders are specified provide friction type at doors without closer and positive type at doors with closer.

2.17 DOOR STOPS AND HOLDERS

A. Manufacturers:

1. Scheduled Manufacturer: Ives.
2. Acceptable Manufacturers: Burns, Rockwood.

B. Provide door stops at each door leaf:

1. Provide wall stops wherever possible. Provide convex type where mortise type locks are used and concave type where cylindrical type locks are used.
2. Where wall stop cannot be used, provide overhead stop.

2.18 THRESHOLDS, SEALS, DOOR SWEEPS, AUTOMATIC DOOR BOTTOMS, AND GASKETING

A. Manufacturers:

1. Scheduled Manufacturer: Zero International.
2. Acceptable Manufacturers: National Guard, Pemko.

B. Requirements:

1. Provide thresholds, weather-stripping (including door sweeps, seals, and astragals) and gasketing systems (including smoke, sound, and light) as specified and per architectural details. Match finish of other items.
2. Smoke- and Draft-Control Door Assemblies: Where smoke- and draft-control door assemblies are required, provide door hardware that meets requirements of assemblies tested according to UL 1784 and installed in compliance with NFPA 105.
3. Size of thresholds:

    a. Saddle Thresholds: 1/2 inch (13 mm) high by jamb width by door width
    b. Bumper Seal Thresholds: 1/2 inch (13 mm) high by 5 inches (127 mm) wide by door width

4. Provide door sweeps, seals, astragals, and auto door bottoms only of type where resilient or flexible seal strip is easily replaceable and readily available.

2.19 SILENCERS

A. Manufacturers:

1. Scheduled Manufacturer: Ives.
2. Acceptable Manufacturers: Burns, Rockwood.

B. Requirements:

1. Provide "push-in" type silencers for hollow metal or wood frames.
2. Provide one silencer per 30 inches (762 mm) of height on each single frame, and two for each pair frame.
3. Omit where gasketing is specified.

2.20 FINISHES

A. Finish: BHMA 626/652 (US26D); except:

1. Hinges at Exterior Doors: BHMA 630 (US32D)
2. Continuous Hinges: BHMA 628 (US28)
3. Push Plates, Pulls, and Push Bars: BHMA 630 (US32D)
4. Protection Plates: BHMA 630 (US32D)
5. Overhead Stops and Holders: BHMA 630 (US32D)
6. Door Closers: Powder Coat to Match
7. Wall Stops: BHMA 630 (US32D)
8. Weatherstripping: Clear Anodized Aluminum
9. Thresholds: Mill Finish Aluminum

PART 3 - EXECUTION

3.01 EXAMINATION

A. Prior to installation of hardware, examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire-rated door assembly construction, wall and floor construction, and other conditions affecting performance.

B. Field verify existing doors and frames receiving new hardware and existing conditions receiving new openings. Verify that new hardware is compatible with existing door and frame preparation and existing conditions.

C. Examine roughing-in for electrical power systems to verify actual locations of wiring connections before electrified door hardware installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Where on-site modification of doors and frames is required:

1. Carefully remove existing door hardware and components being reused. Clean, protect, tag, and store in accordance with storage and handling requirements specified herein.
2. Field modify and prepare existing door and frame for new hardware being installed.
3. When modifications are exposed to view, use concealed fasteners, when possible.
4. Prepare hardware locations and reinstall in accordance with installation requirements for new door hardware and with:

a. Steel Doors and Frames: For surface applied door hardware, drill and tap doors and frames according to ANSI/SDI A250.6.
b. Doors in rated assemblies: NFPA 80 for restrictions on on-site door hardware preparation.

3.03 INSTALLATION

A. Mount door hardware units at heights to comply with the following, unless otherwise indicated or required to comply with governing regulations.

1. Standard Steel Doors and Frames: ANSI/SDI A250.8.
2. Custom Steel Doors and Frames: HMMA 831.

B. Install each hardware item in compliance with manufacturer’s instructions and recommendations, using only fasteners provided by manufacturer.

C. Do not install surface mounted items until finishes have been completed on substrate. Protect all installed hardware during painting.

D. Set units level, plumb and true to line and location. Adjust and reinforce attachment substrate as necessary for proper installation and operation.

E. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.

F. Install operating parts so they move freely and smoothly without binding, sticking, or excessive clearance.

G. Hinges: Install types and in quantities indicated in door hardware schedule but not fewer than quantity recommended by manufacturer for application indicated or one hinge for every 30 inches (750 mm) of door height, whichever is more stringent, unless other equivalent means of support for door, such as spring hinges or pivots, are provided.

H. Lock Cylinders: Install construction cores to secure building and areas during construction period.

1. Replace construction cores with permanent cores as indicated in keying section.

I. Wiring: Coordinate with Division 26, ELECTRICAL sections for:

1. Conduit, junction boxes and wire pulls.
2. Connections to and from power supplies to electrified hardware.
3. Connections to fire/smoke alarm system and smoke evacuation system.
4. Connection of wire to door position switches and wire runs to central room or area, as directed by Architect.
5. Testing and labeling wires with Architect’s opening number.

J. Door Closers: Mount closers on room side of corridor doors, inside of exterior doors, and stair side of stairway doors from corridors. Mount closers so they are not visible in corridors, lobbies and other public spaces unless approved by Architect.

K. Closer/Holders: Mount closer/holders on room side of corridor doors, inside of exterior doors, and stair side of stairway doors.

L. Power Supplies: Locate power supplies as indicated or, if not indicated, above accessible ceilings or in equipment room, or alternate location as directed by Architect.

1. Provide least number of power supplies required to adequately service doors with electrified door hardware.

M. Thresholds: Set thresholds in full bed of sealant complying with requirements specified in Division 07 Section "Joint Sealants."

N. Stops: Provide floor stops for doors unless wall or other type stops are indicated in door hardware schedule. Do not mount floor stops where they may impede traffic or present tripping hazard.

O. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.

P. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.

Q. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

3.04 FIELD QUALITY CONTROL

A. Architectural Hardware Consultant: Engage qualified independent Architectural Hardware Consultant to perform inspections and to prepare inspection reports.

1. Architectural Hardware Consultant will inspect door hardware and state in each report whether installed work complies with or deviates from requirements, including whether door hardware is properly installed and adjusted.

3.05 FIELD INSPECTIONS:

A. Fire Door Assembly Inspection and Testing: Provide functional testing and inspection of fire door assemblies in accordance with NFPA 80-2007/2010. Inspections shall be performed by individuals certified by Intertek as a Fire Door Assembly Inspector, using reporting forms provided by the Door and Hardware Institute (DHI). Alternatively, inspections may be performed by individuals acceptable to the Architect, who have knowledge and understanding of the operating components of the applicable door type, and who have experience in preparing written reports of testing and inspection results.

1. Schedule fire door assembly inspection within 90 days of Substantial Completion of the Project.
2. Submit a signed, written final report as specified in Paragraph 1.4: Submittals.
3. Contractor shall correct all deficiencies and schedule a reinspection of fire door assemblies which were noted as deficient on the inspection report.
4. Inspector shall reinspect fire door assemblies after repairs are made.
5. Additional reinspections which are required due to incomplete repairs will be performed by the inspector at the expense of the Contractor.

3.06 ADJUSTING

A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for

final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.

1. Door Closers: Adjust sweep period to comply with accessibility requirements and requirements of authorities having jurisdiction.

B. Occupancy Adjustment: Approximately three to six months after date of Substantial Completion, Installer's Architectural Hardware Consultant must examine and readjust each item of door hardware, including adjusting operating forces, as necessary to ensure function of doors and door hardware.

3.07 CLEANING AND PROTECTION

A. Clean adjacent surfaces soiled by door hardware installation.

B. Clean operating items as necessary to restore proper function and finish.

C. Provide final protection and maintain conditions that ensure door hardware is without damage or deterioration at time of Substantial Completion.

3.08 DEMONSTRATION

A. Provide training for Owner’s maintenance personnel to adjust, operate, and maintain door hardware and door hardware finishes. Refer to Division 01 Section “Demonstration and Training”.

END OF SECTION 084100

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SECTION 088000 - GLAZING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Glass for window, doors, interior borrowed lites, storefront framing, glazed curtain walls.
2. Glazing sealants and accessories.

B. Related Requirements:

1. Section 081113 “Hollow Metal Doors and Frames”.
2. Section 084213 “Aluminum Framed Entrances”.
3. Section 084413 “Glazed Aluminum Curtain Walls”.

1.3 DEFINITIONS

A. Glass Manufacturers: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.

B. Glass Thicknesses: Indicated by thickness designations in millimeters according to ASTM C 1036.

C. IBC: International Building Code.

D. Interspace: Space between lites of an insulating-glass unit.

1.4 COORDINATION

A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
2. Review temporary protection requirements for glazing during and after installation.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For field-applied glazing sealants, documentation including printed statement of VOC content.

C. Glass Samples: For each type of glass product other than clear monolithic vision glass; 12 inches (300 mm) square.

D. Glazing Accessory Samples: For sealants, in 12-inch (300-mm) lengths.

E. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturers of insulating-glass units with sputter-coated, low-E coatings.

B. Product Certificates: For glass.

C. Product Test Reports: For coated glass, insulating glass, and glazing sealants, for tests performed by a qualified testing agency.

1. For glazing sealants, provide test reports based on testing current sealant formulations within previous 36-month period.

D. Preconstruction adhesion and compatibility test report.

E. Sample Warranties: For special warranties.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications for Insulating-Glass Units with Sputter-Coated, Low-E Coatings: A qualified insulating-glass manufacturer who is approved and certified by coated-glass manufacturer.

B. Glass Testing Agency Qualifications: A qualified independent testing agency accredited according to the NFRC CAP 1 Certification Agency Program.

C. Mockups: Build mockups to demonstrate aesthetic effects and to set quality standards for materials and execution.

1. Install glazing in mockups specified in Section 084413 "Glazed Aluminum Curtain Walls" to match glazing systems required for Project, including glazing methods.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect glazing materials according to manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

1.10 FIELD CONDITIONS

A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.

1.11 WARRANTY

A. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.

1. Warranty Period: 10 years from date of Substantial Completion.

B. Manufacturer's Special Warranty for Laminated Glass: Manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination

materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.

1. Warranty Period: Five years from date of Substantial Completion.

C. Manufacturer's Special Warranty for Insulating Glass: Manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Glass: Obtain from single source from single manufacturer for each glass type.

1. Obtain tinted glass from single source from single manufacturer.
2. Obtain reflective-coated glass from single source from single manufacturer.

B. Source Limitations for Glazing Accessories: Obtain from single source from single manufacturer for each product and installation method.

2.2 PERFORMANCE REQUIREMENTS

A. General: Installed glazing systems shall withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.

B. Structural Performance: Glazing shall withstand the following design loads within limits and under conditions indicated determined according to the IBC and ASTM E 1300.

1. Design Wind Pressures: As indicated on Drawings.
2. Design Wind Pressures: Determine design wind pressures applicable to Project according to ASCE/SEI 7, based on heights above grade indicated on Drawings.

a. Wind Design Data: As indicated on Drawings.
b. Basic Wind Speed: [**85 mph (38 m/s)**] [**90 mph (40 m/s)**] [**100 mph (44 m/s)**] [**110 mph (49 m/s)**] <**Insert value**>.
c. Importance Factor: [**1.0**] <**Insert factor**>.

d. Exposure Category: [**B**] [**C**] [**D**].

3. Design Snow Loads: As indicated on Drawings.
4. Maximum Lateral Deflection: For glass supported on all four edges, limit center-of-glass deflection at design wind pressure to not more than 1/50 times the short-side length or 1 inch (25 mm), whichever is less.
5. Differential Shading: Design glass to resist thermal stresses induced by differential shading within individual glass lites.

C. Windborne-Debris-Impact Resistance: Exterior glazing shall comply with [**basic**] [**enhanced**]-protection testing requirements in ASTM E 1996 for [**Wind Zone 1**] [**Wind Zone 2**] [**Wind Zone 3**] [**Wind Zone 4**] when tested according to ASTM E 1886. Test specimens shall be no smaller in width and length than glazing indicated for use on Project and shall be installed in same manner as glazing indicated for use on Project.

1. Large-Missile Test: For glazing located within 30 feet (9.1 m) of grade.
2. Small-Missile Test: For glazing located more than 30 feet (9.1 m) above grade.

D. Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.

E. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:

1. For monolithic-glass lites, properties are based on units with lites of thickness indicated.
2. For laminated-glass lites, properties are based on products of construction indicated.
3. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.
4. U-Factors: Center-of-glazing values, according to NFRC 100 and based on LBL's WINDOW 5.2 computer program, expressed as Btu/sq. ft. x h x deg F (W/sq. m x K).
5. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL's WINDOW 5.2 computer program.
6. Visible Reflectance: Center-of-glazing values, according to NFRC 300.

2.3 GLASS PRODUCTS, GENERAL

A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.

1. GANA Publications: "Laminated Glazing Reference Manual" and "Glazing Manual."

2. IGMA Publication for Insulating Glass: SIGMA TM-3000, "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use."

B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the SGCC. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

C. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of IGCC.

D. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than the thickness indicated.

1. Minimum Glass Thickness for Exterior Lites: 6 mm.

E. Strength: Where annealed float glass is indicated, provide annealed float glass, heat-strengthened float glass, or fully tempered float glass as needed to comply with "Performance Requirements" Article. Where heat-strengthened float glass is indicated, provide heat-strengthened float glass or fully tempered float glass as needed to comply with "Performance Requirements" Article. Where fully tempered float glass is indicated, provide fully tempered float glass.

2.4 GLASS PRODUCTS

A. Clear Annealed Float Glass: ASTM C 1036, Type I, Class 1 (clear), Quality-Q3.

B. Fully Tempered Float Glass: ASTM C 1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.

C. Heat-Strengthened Float Glass: ASTM C 1048, Kind HS (heat strengthened), Type I, Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.

2.5 LAMINATED GLASS

A. Laminated Glass: ASTM C 1172. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.

1. Construction: Laminate glass with polyvinyl butyral interlayer to comply with interlayer manufacturer's written instructions.
2. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.
3. Interlayer Color: Clear unless otherwise indicated.

2.6 INSULATING GLASS

A. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E 2190.

1. Sealing System: Dual seal, with polyisobutylene and silicone primary and secondary sealants.
2. Spacer: Manufacturer's standard spacer material and construction.
3. Desiccant: Molecular sieve or silica gel, or a blend of both.

2.7 GLAZING SEALANTS

A. General:

1. Compatibility: Compatible with one another and with other materials they contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
3. Field-applied sealants shall have a VOC content of not more than 250 g/L.
4. Colors of Exposed Glazing Sealants: As selected by Architect from manufacturer's full range.

B. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use NT.

2.8 GLAZING TAPES

A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C 1281 and AAMA 800 for products indicated below:

1. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
2. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

B. Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; and complying with AAMA 800 for the following types:

1. AAMA 810.1, Type 1, for glazing applications in which tape acts as the primary sealant.
2. AAMA 810.1, Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.

2.9 MISCELLANEOUS GLAZING MATERIALS

A. General: Provide products of material, size, and shape complying with referenced glazing standard, with requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.

B. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

C. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.

D. Spacers: Elastomeric blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.

E. Edge Blocks: Elastomeric material of hardness needed to limit glass lateral movement (side walking).

2.10 FABRICATION OF GLAZING UNITS

A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.

1. Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.

a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:

1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
2. Presence and functioning of weep systems.
3. Minimum required face and edge clearances.
4. Effective sealing between joints of glass-framing members.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

B. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that leave visible marks in the completed Work.

3.3 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

B. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.

C. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

D. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

E. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

F. Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).

1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
2. Provide 1/8-inch (3-mm) minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

G. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

H. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.

I. Set glass lites with proper orientation so that coatings face exterior or interior as specified.

J. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.

K. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended by gasket manufacturer.

3.4 TAPE GLAZING

A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

C. Cover vertical framing joints by applying tapes to heads and sills first, then to jambs. Cover horizontal framing joints by applying tapes to jambs, then to heads and sills.

D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

E. Do not remove release paper from tape until right before each glazing unit is installed.

F. Apply heel bead of elastomeric sealant.

G. Center glass lites in openings on setting blocks, and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

3.5 GASKET GLAZING (DRY)

A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

E. Install gaskets so they protrude past face of glazing stops.

3.6 CLEANING AND PROTECTION

A. Immediately after installation remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.

1. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer. Remove and replace glass that cannot be cleaned without damage to coatings.

C. Remove and replace glass that is damaged during construction period.

3.7 MONOLITHIC GLASS

A. Glass Type: Clear, fully tempered float glass.

1. Minimum Thickness: ¼ inch (6 mm).
2. Safety glazing required.

3.8 LAMINATED GLASS

A. Glass Type: Clear laminated glass with two plies of heat-strengthened float glass.

1. Minimum Thickness of Each Ply: 3 mm.
2. Interlayer Thickness: 0.030 inch (0.76 mm).
3. Safety glazing required.

3.9 INSULATING GLASS

A. Glass Type: Low-E-coated, clear insulating glass.

1. Basis-of-Design Product: Viracon VRE1-4725.
2. Overall Unit Thickness: 1 inch (25 mm).
3. Minimum Thickness of Each Glass Lite: 6 mm.
4. Outdoor Lite: Fully tempered float glass.
5. Interspace Content: Argon.
6. Indoor Lite: Fully tempered float glass.
7. Low-E Coating: Sputtered on second surface.
8. Winter Nighttime U-Factor: 0.25 maximum.
9. Summer Daytime U-Factor: 0.21 maximum.
10. Visible Light Transmittance: 47 percent minimum.
11. Solar Heat Gain Coefficient: 0.25 maximum.
12. Safety glazing required.

B. Glass Type: Ceramic-coated, low-E, insulating spandrel glass.

1. Basis-of-Design Product: Viracon VRE1-4725.
2. Coating Color: As selected by Architect from manufacturer's full range.
3. Overall Unit Thickness: 1 inch (25 mm).
4. Minimum Thickness of Each Glass Lite: 6 mm.
5. Outdoor Lite: Fully tempered float glass.
6. Interspace Content: Argon.
7. Indoor Lite: Fully tempered ¼” clear Viraspan V954 gray #2 float glass.
8. Low-E Coating: Sputtered on second surface.
9. Opaque Coating Location: Fourth surface.
10. Winter Nighttime U-Factor: 0.25 maximum.
11. Summer Daytime U-Factor: 0.21 maximum.

END OF SECTION 088000

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SECTION 089119 - FIXED LOUVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fixed, extruded-aluminum louvers.

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades (i.e., the axes of the blades are horizontal).

C. Vertical Louver: Louver with vertical blades (i.e., the axes of the blades are vertical).

D. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

E. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
2. Show mullion profiles and locations.

C. Samples: For each type of metal finish required.

D. Delegated-Design Submittal: For louvers indicated to comply with structural and seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.6 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design louvers, including comprehensive engineering analysis by a qualified professional engineer, using structural and seismic performance requirements and design criteria indicated.

B. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on pressures as indicated on Drawings.

2. Wind Loads: Determine loads based on a uniform pressure of [**20 lbf/sq. ft. (957 Pa)**] [**30 lbf/sq. ft. (1436 Pa)**] <**Insert value**>, acting inward or outward.
3. Wind Loads: Determine loads based on pressures indicated below:

    a. Corner Zone: Within <**Insert distance**> of building corners, uniform pressure of <**Insert design wind pressure**>, acting inward, and <**Insert design wind pressure**>, acting outward.
    b. Other Than Corner Zone: Uniform pressure of <**Insert design wind pressure**>, acting inward, and <**Insert design wind pressure**>, acting outward.

C. Windborne-Debris-Impact Resistance: Louvers located within 30 feet (9.1 m) of grade shall pass [**basic**] [**enhanced**]-protection, large-missile testing requirements in ASTM E 1996 for [**Wind Zone 1**] [**Wind Zone 2**] [**Wind Zone 3**] [**Wind Zone 4**] when tested according to ASTM E 1886. Test specimens shall be no smaller in width and length than louvers indicated for use on Project.

D. Seismic Performance: Louvers, including attachments to other construction, shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. Design earthquake spectral response acceleration, short period (Sds) for Project is <**Insert value**>.
2. Component Importance Factor: [**1.5**] [**1.0**].

E. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

G. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.3 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Continuous Blade, Hidden Mullion, Nondrainable-Blade Louver:

1. Basis-of-Design: Greenheck ESJ 602 RM and ESJ 602 HM.
2. 6 inches (150 mm).
3. Blade Profile: Plain blade without center baffle.
4. Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm).
5. Mullion Type: Concealed.
6. Louver Performance Ratings:

a. Free Area: Not less than 8.5 sq. ft. (0.79 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
b. Point of Beginning Water Penetration: Not less than 735 fpm.
c. Air Performance: Not more than 0.090 inch wg static pressure drop at 6450 cfm free-area exhaust velocity.

B. Horizontal, Drainable-Blade Louver:

1. Basis-of-Design: Greenheck ESD 635.
2. Louver Depth: 6 inches (150 mm).
3. Frame and Blade Nominal Thickness: Not less than 0.080 inch (2.03 mm).
4. Mullion Type: Exposed.
5. Louver Performance Ratings:

a. Free Area: Not less than 9.4 sq. ft. for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
b. Point of Beginning Water Penetration: Not less than 1250 fpm.
c. Air Performance: Not more than 0.065-inch wg static pressure drop at 6000 cfm free-area intake velocity.

6. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 LOUVER SCREENS

A. General: Provide screen at each exterior louver.

1. Screen Location for Fixed Louvers: Interior face.
2. Screening Type: Bird screening except where insect screening is indicated.

B. Secure screen frames to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches (150 mm) from each corner and at 12 inches (300 mm) o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.

1. Metal: Same type and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
2. Finish: Same finish as louver frames to which louver screens are attached.

D. Louver Screening for Aluminum Louvers:

1. Bird Screening: Aluminum, 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.60-mm) wire.

2.5 BLANK-OFF PANELS

A. Uninsulated, Blank-Off Panels: Metal sheet attached to back of louver.

1. Aluminum sheet for aluminum louvers, not less than 0.050-inch (1.27-mm) nominal thickness.
2. Panel Finish: Same finish type applied to louvers, but black color.
3. Location: Unconditioned space.

B. Insulated, Blank-Off Panels: Laminated panels consisting of an insulating core surfaced on back and front with metal sheets and attached to back of louver.

1. Thickness: 2 inches (50 mm).
2. Metal Facing Sheets: Aluminum sheet, not less than 0.032-inch (0.81-mm) nominal thickness.
3. Insulating extruded-polystyrene foam.
4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard channel frames, with corners mitered and with same finish as panels.
5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
6. Panel Finish: Same type of finish applied to louvers, but black color.
7. Location: Conditioned space.

2.6 MATERIALS

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.

1. Use Phillips flat-head screws for exposed fasteners unless otherwise indicated.
2. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
3. For fastening galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.
4. For color-finished louvers, use fasteners with heads that match color of louvers.

D. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.7 FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.

1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated.
2. Horizontal Mullions: Provide horizontal mullions at joints where indicated.

C. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.

D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

1. Frame Type: Channel unless otherwise indicated.

E. Include supports, anchorages, and accessories required for complete assembly.

F. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches (1830 mm) o.c., whichever is less.

1. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
2. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.

G. Provide extended sills for recessed louvers.

H. Join frame members to each other and to fixed louver blades with fillet welds concealed from view, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

I. Coordinate extent, configuration, and fastening of blank-off panels with support structure, dampers, and ductwork.

2.8 ALUMINUM FINISHES

A. Finish louvers after assembly.

B. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 50 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Color and Gloss: Match Architect's sample.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Protect unpainted galvanized and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 079200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 089119

SECTION 092216 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Non-load-bearing steel framing systems for interior partitions.
2. Suspension systems for interior ceilings and soffits.
3. Grid suspension systems for gypsum board ceilings.

B. Related Requirements:

1. Section 054000 "Cold-Formed Metal Framing" for exterior and interior load-bearing and exterior non-load-bearing wall studs; floor joists; roof rafters and ceiling joists; and roof trusses.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Studs and Runners: Provide documentation that framing members' certification is according to SIFA's "Code Compliance Certification Program for Cold-Formed Steel Structural and Non-Structural Framing Members."

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

1.4 INFORMATIONAL SUBMITTALS

A. Evaluation Reports: For embossed steel studs and runners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Horizontal Deflection: For wall assemblies, limited to 1/240 of the wall height based on horizontal loading of 5 lbf/sq. ft. (239 Pa).

2.2 FRAMING SYSTEMS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Framing Members, General: Comply with ASTM C 754 for conditions indicated.

1. Steel Sheet Components: Comply with ASTM C 645 requirements for metal unless otherwise indicated.
2. Protective Coating: ASTM A 653/A 653M, G40 (Z120), hot-dip galvanized unless otherwise indicated.

C. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches (32 mm), wall attachment flange of 7/8 inch (22 mm), minimum uncoated-metal thickness of 20 gauge, and depth required to fit insulation thickness indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Clark Steel Framing Systems.
b. Dale Industries.
c. Dietrich Industries.
d. Marinoware.

2.3 SUSPENSION SYSTEMS

A. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

B. Hanger Attachments to Concrete:

1. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E 488/E 488M conducted by a qualified testing agency.
2. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the

design load, as determined by testing per ASTM E 1190 conducted by a qualified testing agency.

C. Wire Hangers: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.16 inch (4.12 mm) in diameter.

D. Flat Hangers: Steel sheet, 1 by 3/16 inch (25 by 5 mm) by length required.

E. Grid Suspension System for Gypsum Board Ceilings: ASTM C 645, direct-hung system composed of main beams and cross-furring members that interlock.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Armstrong World Industries, Inc; Drywall Grid Systems.
b. Chicago Metallic Corporation; 640/660 Drywall Ceiling Suspension.
c. United State Gypsum Company; Drywall Suspension System.

2.4 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards.

1. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

B. Isolation Strip at Exterior Walls: Provide one of the following:

1. Asphalt-Saturated Organic Felt: ASTM D 226/D 226M, Type I (No. 15 asphalt felt), nonperforated.
2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch (3.2 mm) thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.

1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.

B. Coordination with Sprayed Fire-Resistive Materials:

1. Before sprayed fire-resistive materials are applied, attach offset anchor plates or ceiling runners (tracks) to surfaces indicated to receive sprayed fire-resistive materials. Where offset anchor plates are required, provide continuous plates fastened to building structure not more than 24 inches (610 mm) o.c.
2. After sprayed fire-resistive materials are applied, remove them only to extent necessary for installation of non-load-bearing steel framing. Do not reduce thickness of fire-resistive materials below that are required for fire-resistance ratings indicated. Protect adjacent fire-resistive materials from damage.

3.3 INSTALLATION, GENERAL

A. Installation Standard: ASTM C 754.

1. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.

B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.

C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.

D. Install bracing at terminations in assemblies.

E. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.4 INSTALLING FRAMED ASSEMBLIES

A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

C. Install studs so flanges within framing system point in same direction.

D. Install tracks (runners) at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts that penetrate partitions above ceiling.

E. Z-Shaped Furring Members:

1. Erect insulation, specified in Section 072100 "Thermal Insulation," vertically and hold in place with Z-shaped furring members spaced 24 inches (610 mm) o.c.
2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.
3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches (305 mm) from corner and cut insulation to fit.

F. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

3.5 INSTALLING SUSPENSION SYSTEMS

A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

1. Hangers: 48 inches (1219 mm) o.c.

B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

C. Suspend hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.

a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.

3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.
4. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
5. Do not attach hangers to steel roof deck.
6. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.
7. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
8. Do not connect or suspend steel framing from ducts, pipes, or conduit.

D. Seismic Bracing: Sway-brace suspension systems with hangers used for support.

E. Grid Suspension Systems: Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

F. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet (3 mm in 3.6 m) measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION 092216

SECTION 092900 - GYPSUM BOARD

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Interior gypsum board.
2. Exterior gypsum board for ceilings and soffits.

B. Related Requirements:

1. Section 061600 "Sheathing" for gypsum sheathing for exterior walls.
2. Section 092216 "Non-Structural Metal Framing" for non-structural steel framing and suspension systems that support gypsum board panels.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
2. Product Data for Credit IEQ 4.1: For adhesives used to laminate gypsum board panels to substrates, documentation including printed statement of VOC content.
3. Laboratory Test Reports for Credit IEQ 4.1: For adhesives used to laminate gypsum board panels to substrates, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

1.4 DELIVERY, STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.5 FIELD CONDITIONS

A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written instructions, whichever are more stringent.

B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned.

C. Do not install panels that are wet, moisture damaged, and mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 GYPSUM BOARD, GENERAL

A. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.2 INTERIOR GYPSUM BOARD

A. Gypsum Board, Type X: ASTM C 1396/C 1396M.

1. Thickness: 5/8 inch (15.9 mm).
2. Long Edges: Tapered.

B. Abuse and Mold-Resistant Gypsum Board: ASTM C 1629/C 1629M.

1. USG MoldTough AR Firecode X Panels or equal.
2. Core: 5/8 inch (15.9 mm), Type X.
3. Surface Abrasion: Meets or exceeds Level 2 requirements.
4. Surface Indentation: Meets or exceeds Level 1 requirements.
5. Single-Drop Soft-Body Impact: Meets or exceeds Level 2 requirements.
6. Long Edges: Tapered.

7. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

C. Glass-Mat Mold-Resistant Interior Gypsum Board: ASTM C 1658/C 1658M. With fiberglass mat laminated to both sides. Specifically designed for interior use.

1. USG Glass Mat MoldTough Firecode X Panels or equal.
2. Core: 5/8 inch (15.9 mm), Type X.
3. Long Edges: Tapered.
4. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

2.3 EXTERIOR GYPSUM BOARD FOR CEILINGS AND SOFFITS

A. Glass-Mat Gypsum Sheathing Board: ASTM C 1177/C 1177M, with fiberglass mat laminated to both sides and with manufacturer's standard edges.

1. Georgia Pacific Dens Glass Gold Sheathing or equal.
2. Core: 5/8 inch (15.9 mm), Type X.

2.4 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Material: Galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized-steel sheet.
2. Shapes:

a. Cornerbead.
b. Bullnose bead.
c. LC-Bead: J-shaped; exposed long flange receives joint compound.
d. L-Bead: L-shaped; exposed long flange receives joint compound.
e. Expansion (control) joint.

B. Exterior Trim: ASTM C 1047.

1. Material: Hot-dip galvanized-steel sheet, plastic, or rolled zinc.
2. Shapes:

a. Cornerbead.
b. LC-Bead: J-shaped; exposed long flange receives joint compound.

2.5 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475/C 475M.

B. Joint Tape:

1. Interior Gypsum Board: Paper.
2. Exterior Gypsum Soffit Board: Paper.
3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.

C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use drying-type, all-purpose compound.

a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use drying-type, all-purpose compound.
4. Finish Coat: For third coat, use setting-type, sandable topping compound.

D. Joint Compound for Exterior Applications:

1. Glass Mat Gypsum Sheathing Board: As recommended by sheathing board manufacturer.

2.6 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.

B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

1. Laminating adhesive shall have VOC content of 50 g/L or less.

C. Steel Drill Screws: ASTM C 1002 unless otherwise indicated.

1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.
2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

D. Sound-Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.

1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

E. Acoustical Joint Sealant: Manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Pecora Corporation AC-20 FTR.
b. USG Corporation Sheetrock Acoustic Sealant.

2. Acoustical joint sealant shall have a VOC content of 250 g/L or less.

F. Thermal Insulation: As specified in Section 072100 "Thermal Insulation."

G. Vapor Retarder: 6 mil polyethylene.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLYING AND FINISHING PANELS, GENERAL

A. Comply with ASTM C 840.

B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.

C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch (1.5 mm) of open space between panels. Do not force into place.

D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite

sides of partitions. Do not make joints other than control joints at corners of framed openings.

E. Form control and expansion joints with space between edges of adjoining gypsum panels.

F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.

1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.
2. Fit gypsum panels around ducts, pipes, and conduits.
3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- (6.4- to 9.5-mm-) wide joints to install sealant.

G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 3/8 inch wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

I. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.3 APPLYING INTERIOR GYPSUM BOARD

1. Abuse-Resistant Type: Throughout except as indicated below.
2. Glass-Mat Interior Type: At Toilet Rooms not covered by tile.

B. Single-Layer Application:

1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated.
2. On partitions/walls, apply gypsum panels vertically (parallel to framing) unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.

    a. Stagger abutting end joints not less than one framing member in alternate courses of panels.

3. On Z-shaped furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

3.4 APPLYING EXTERIOR GYPSUM PANELS FOR CEILINGS AND SOFFITS

A. Apply panels perpendicular to supports, with end joints staggered and located over supports.

1. Install with 1/4-inch (6.4-mm) open space where panels abut other construction or structural penetrations.
2. Fasten with corrosion-resistant screws.

3.5 INSTALLING TRIM ACCESSORIES

A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Control Joints: Install control joints according to ASTM C 840 and in specific locations approved by Architect for visual effect.

C. Interior Trim: Install in the following locations:

1. Cornerbead: Use at outside corners unless otherwise indicated.
2. Bullnose Bead: Use at outside corners.
3. LC-Bead: Use at exposed panel edges.
4. L-Bead: Use where indicated.

D. Exterior Trim: Install in the following locations:

1. Cornerbead: Use at outside corners.
2. LC-Bead: Use at exposed panel edges.

3.6 FINISHING GYPSUM BOARD

A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints, rounded or beveled edges, and damaged surface areas.

C. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:

1. Level 2: Panels that are concealed areas.

2. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.

    a. Primer and its application to surfaces are specified in Section 099123 "Interior Painting."

E. Glass-Mat Gypsum Sheathing Board: Finish according to manufacturer's written instructions for use as exposed soffit board.

F. Glass-Mat Faced Panels: Finish according to manufacturer's written instructions.

3.7 PROTECTION

A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.

B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

C. Remove and replace panels that are wet, moisture damaged, and mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION 092900

SECTION 095113 - ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes acoustical panels and exposed suspension systems for ceilings.

B. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
2. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

C. Samples: For each exposed product and for each color and texture specified, 6 inches (150 mm) in size.

1. Acoustical Panel: Set of 6-inch- (150-mm-) square Samples of each type, color, pattern, and texture.
2. Exposed Suspension-System Members, Moldings, and Trim: Set of 6-inch- (150-mm-) long Samples of each type, finish, and color.

1.5 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each acoustical panel ceiling, for tests performed by a qualified testing agency.

B. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and fastener type, from ICC-ES.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Acoustical Ceiling Panels: Full-size panels equal to 2 percent of quantity installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to NVLAP for testing indicated.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical panels, suspension-system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

C. Handle acoustical panels carefully to avoid chipping edges or damaging units in any way.

1.10 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Acoustical ceiling shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: Comply with ASTM E 1264 for Class A materials.
2. Smoke-Developed Index: 50 or less.

2.2 ACOUSTICAL PANELS, GENERAL

A. Source Limitations: Obtain each type of acoustical ceiling panel and supporting suspension system from single source from single manufacturer.

B. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 50 percent.

C. Glass-Fiber-Based Panels: Made with binder containing no urea formaldehyde.

D. Acoustical Panel Standard: Provide manufacturer's standard panels of configuration indicated that comply with ASTM E 1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances unless otherwise indicated.

1. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches (400 mm) away from test surface according to ASTM E 795.

E. Acoustical Panel Colors and Patterns: Match appearance characteristics indicated for each product type.

2.3 ACOUSTICAL PANELS

A. Classification: Provide panels complying with ASTM E 1264 for type, form, and pattern as follows:

1. Type and Form: Type IV, mineral base with membrane-faced overlay; Form 2, water felted.
2. Pattern: E (lightly textured).

B. Color: White.

C. LR: Not less than 0.87.

D. NRC: Not less than 0.80.

E. CAC: Not less than 35.

F. AC: Not less than 170.

G. Edge/Joint Detail: Reveal sized to fit flange of exposed suspension-system members.

H. Thickness: 7/8 inch (22 mm).

I. Modular Size: 24 by 24 inches (610 by 610 mm).

J. Broad Spectrum Antimicrobial Fungicide and Bactericide Treatment: Provide acoustical panels treated with manufacturer's standard antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested according to ASTM D 3273 and evaluated according to ASTM D 3274 or ASTM G 21.

2.4 METAL SUSPENSION SYSTEMS, GENERAL

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Metal Suspension-System Standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C 635/C 635M.

1. High-Humidity Finish: Comply with ASTM C 635/C 635M requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated.

C. Attachment Devices: Size for five times the design load indicated in ASTM C 635/C 635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.

1. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing according to ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.

a. Type: Postinstalled expansion or Postinstalled bonded anchors.
b. Corrosion Protection: Components fabricated from nickel-copper-alloy rods complying with ASTM B 164 for UNS No. N04400 alloy.

2. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with

capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing according to ASTM E 1190, conducted by a qualified testing and inspecting agency.

D. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:

1. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
2. Size: Select wire diameter so its stress at three times hanger design load (ASTM C 635/C 635M, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) diameter wire.

E. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.

F. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed with 0.04-inch- (1-mm-) thick, galvanized-steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.

G. Seismic Stabilizer Bars: Manufacturer's standard perimeter stabilizers designed to accommodate seismic forces.

H. Seismic Struts: Manufacturer's standard compression struts designed to accommodate seismic forces.

I. Seismic Clips: Manufacturer's standard seismic clips designed and spaced to secure acoustical panels in place.

2.5 METAL SUSPENSION SYSTEM

A. Wide-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet; prepainted, electrolytically zinc coated, or hot-dip galvanized according to ASTM A 653/A 653M, not less than G30 (Z90) coating designation (G60 at Toilet Rooms with showers); with prefinished 15/16-inch- (24-mm-) wide metal caps on flanges.

1. Structural Classification: Intermediate-duty system.
2. End Condition of Cross Runners: Override (stepped) type.
3. Face Design: Flat, flush.
4. Cap Material: Steel cold-rolled sheet.
5. Cap Finish: Painted white.

2.6 METAL EDGE MOLDINGS AND TRIM

A. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply

with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners.

1. Provide manufacturer's standard edge moldings that fit acoustical panel edge details and suspension systems indicated and that match width and configuration of exposed runners unless otherwise indicated.
2. For circular and bullnose penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.

2.7 ACOUSTICAL SEALANT

A. Acoustical Sealant: Manufacturer's standard sealant complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

1. Exposed and Concealed Joints: Nonsag, paintable, nonstaining latex sealant.
2. Concealed Joints: Nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant.
3. Acoustical sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.

B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

3.3 INSTALLATION

A. General: Install acoustical panel ceilings to comply with ASTM C 636/C 636M and seismic design requirements indicated, according to manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both the structure to which hangers are attached and the type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
8. Do not attach hangers to steel deck tabs.
9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
10. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.

C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.

D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.

1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
2. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

E. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

F. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.

1. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
2. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
3. Protect lighting fixtures and air ducts to comply with requirements indicated for fire-resistance-rated assembly.
4. Provide all moldings, trim, and accessories for a complete installation.

3.4 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 095113

SECTION 096513 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Resilient base.
2. Resilient stair accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4.1: For adhesives, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Product Data for Credit IEQ 4.3: For adhesives, documentation including printed statement of VOC content.
4. Product Data for Credit IEQ 4.3: For resilient stair accessories, documentation from an independent testing agency indicating compliance with the FloorScore standard.

C. Samples for Initial Selection: For each type of product indicated.

D. Product Schedule: For resilient base and accessory products. Use same designations indicated on Drawings.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Furnish not less than 10 linear feet (3 linear m) or fraction thereof, of each type, color, pattern, and size of resilient product installed.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C).

1.6 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 95 deg F (35 deg C), in spaces to receive resilient products during the following time periods:

1. 48 hours before installation.
2. During installation.
3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).

C. Install resilient products after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. FloorScore Compliance: Resilient base and stair accessories shall comply with requirements of FloorScore certification.

2.2 THERMOSET-RUBBER BASE

A. Product Standard: ASTM F 1861, Type TS (rubber, vulcanized thermoset), Group I (solid, homogeneous).

1. Style and Location:

a. Style B, Cove: Provide in areas with resilient flooring.

B. Thickness: 0.125 inch (3.2 mm).

C. Height: 4 inches (102 mm).

D. Lengths: Coils in manufacturer's standard length.

E. Outside Corners: Job formed.

F. Inside Corners: Job formed.

G. Colors: Match Architect's sample.

2.3 RUBBER STAIR ACCESSORIES

A. Fire-Test-Response Characteristics: As determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.

1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

B. Stair Treads: ASTM F 2169.

1. Type: TS (rubber, vulcanized thermoset).
2. Class: 2 (embossed).
3. Group: 1 (embedded abrasive strips).
4. Nosing Style: Square, adjustable to cover angles between 60 and 90 degrees.
5. Nosing Height: 1-3/4 inches.
6. Thickness: 1/4 inch (6 mm) and tapered to back edge.
7. Size: Lengths and depths to fit each stair tread in one piece.
8. Integral Risers: Smooth, flat; in height that fully covers substrate.

C. Landing Tile: Produced by same manufacturer as treads and recommended by manufacturer for installation with treads. Refer to Section 096516 “Resilient Sheet Flooring”.

D. Locations: Provide rubber stair accessories in areas indicated.

E. Colors and Patterns: Match Architect's sample.

2.4 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by resilient-product manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by resilient-product manufacturer for resilient products and substrate conditions indicated.

1. Adhesives shall have a VOC content of 50 g/L or less except that adhesive for rubber stair treads shall have a VOC content of 60 g/L or less.

C. Stair-Tread Nose Filler: Two-part epoxy compound recommended by resilient stair-tread manufacturer to fill nosing substrates that do not conform to tread contours.

D. Metal Edge Strips: Extruded aluminum with mill finish of width shown, of height required to protect exposed edges of flooring, and in maximum available lengths to minimize running joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Installation of resilient products indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates for Resilient Stair Accessories: Prepare horizontal surfaces according to ASTM F 710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 9 pH.

4. Moisture Testing: Proceed with installation only after substrates pass testing according to manufacturer's written recommendations, but not less stringent than the following:

    a. Perform anhydrous calcium chloride test according to ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.
    b. Perform relative humidity test using in situ probes according to ASTM F 2170. Proceed with installation only after substrates have maximum 75 percent relative humidity level.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install resilient products until they are the same temperature as the space where they are to be installed.

1. At least 48 hours in advance of installation, move resilient products and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient products.

3.3 RESILIENT BASE INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient base.

B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

C. Install resilient base in lengths as long as practical without gaps at seams and with tops of adjacent pieces aligned.

D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.

E. Do not stretch resilient base during installation.

F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.

G. Job-Formed Corners:

1. Outside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches (76 mm) in length.

    a. Form without producing discoloration (whitening) at bends.

2. Inside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches (76 mm) in length.

    a. Miter or cope corners to minimize open joints.

3.4 RESILIENT ACCESSORY INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient accessories.

B. Resilient Stair Accessories:

1. Use stair-tread-nose filler to fill nosing substrates that do not conform to tread contours.
2. Tightly adhere to substrates throughout length of each piece.

3.5 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting resilient products.

B. Perform the following operations immediately after completing resilient-product installation:

1. Remove adhesive and other blemishes from exposed surfaces.
2. Sweep and vacuum horizontal surfaces thoroughly.
3. Damp-mop horizontal surfaces to remove marks and soil.

C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover resilient products subject to wear and foot traffic until Substantial Completion.

END OF SECTION 096513

SECTION 096516 - RESILIENT SHEET FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes rubber sheet flooring and base skirting.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives[**and chemical-bonding compounds**], documentation including printed statement of VOC content.
2. Product Data for Credit IEQ 4.3: For adhesives[**and chemical-bonding compounds**], documentation including printed statement of VOC content.
3. Product Data for Credit IEQ 4.3: For resilient sheet flooring, documentation from an independent testing agency indicating compliance with the FloorScore standard.

C. Samples: For each exposed product and for each color and texture specified in manufacturer's standard size, but not less than 6-by-9-inch (150-by-230-mm) sections.

1. For heat-welding bead, manufacturer's standard-size Samples, but not less than 9 inches (230 mm) long, of each color required.

D. Welded-Seam Samples: For seamless-installation technique indicated and for each resilient sheet flooring product, color, and pattern required; with seam running lengthwise and in center of 6-by-9-inch (150-by-230-mm) Sample applied to a rigid backing and prepared by Installer for this Project.

E. Product Schedule: For resilient sheet flooring. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of resilient sheet flooring to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Resilient Sheet Flooring: Furnish not less than 10 linear feet (3 linear m) for every 500 linear feet (150 linear m) or fraction thereof, in roll form and in full roll width for each type, color, and pattern of flooring installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for resilient sheet flooring installation and seaming method indicated.

1. Engage an installer who employs workers for this Project who are trained or certified by resilient sheet flooring manufacturer for installation techniques required.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store resilient sheet flooring and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C). Store rolls upright.

1.9 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 85 deg F (29 deg C), in spaces to receive resilient sheet flooring during the following time periods:

1. 48 hours before installation.
2. During installation.
3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).

C. Close spaces to traffic during resilient sheet flooring installation.

D. Close spaces to traffic for 48 hours after resilient sheet flooring installation.

E. Install resilient sheet flooring after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. FloorScore Compliance: Resilient sheet flooring shall comply with requirements of FloorScore certification.

2.2 UNBACKED RUBBER SHEET FLOORING (RS01 and RS02)

A. Product Standard: ASTM F 1859.

1. Type: Type I (homogeneous rubber sheet).
2. Thickness: As indicated.
3. Hardness: Manufacturer's standard hardness, measured using Shore, Type A durometer per ASTM D 2240.

B. Wearing Surface: RS01: Smooth; RS02: Textured.

C. Sheet Width: RS01: 4.0 feet (1.2 m); RS02: 40” x 40”.

D. Seamless-Installation Method: Heat welded.

E. Colors and Patterns: Match Architect's sample.

2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by resilient sheet flooring manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by flooring and adhesive manufacturers to suit resilient sheet flooring and substrate conditions indicated.

1. Adhesives shall have a VOC content of 60 g/L or less.

C. Seamless-Installation Accessories:

1. Heat-Welding Bead: Manufacturer's solid-strand product for heat welding seams.

a. Color: Match flooring.

D. Sanitary Cove-Base Accessories:

1. Smooth surface, preformed hygienic skirting, 6” vertical, 3” horizontal.
2. Install in Toilet Rooms.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient sheet flooring.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to resilient sheet flooring manufacturer's written instructions to ensure adhesion of resilient sheet flooring.

B. Concrete Substrates: Prepare according to ASTM F 710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by resilient sheet flooring manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by resilient sheet flooring manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 9 pH.
4. Moisture Testing: Proceed with installation only after substrates pass testing according to resilient sheet flooring manufacturer's written recommendations, but not less stringent than the following:

a. Perform relative humidity test using in situ probes according to ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install resilient sheet flooring until it is the same temperature as the space where it is to be installed.

1. At least 48 hours in advance of installation, move flooring and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient sheet flooring.

3.3 RESILIENT SHEET FLOORING INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient sheet flooring.

B. Unroll resilient sheet flooring and allow it to stabilize before cutting and fitting.

C. Lay out resilient sheet flooring as follows:

1. Maintain uniformity of flooring direction.
2. Minimize number of seams; place seams in inconspicuous and low-traffic areas, at least 6 inches (152 mm) away from parallel joints in flooring substrates.
3. Match edges of flooring for color shading at seams.
4. Avoid cross seams.

D. Scribe and cut resilient sheet flooring to butt neatly and tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, and door frames.

E. Extend resilient sheet flooring into toe spaces, door reveals, closets, and similar openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on resilient sheet flooring as marked on substrates. Use chalk or other nonpermanent marking device.

G. Install resilient sheet flooring on covers for telephone and electrical ducts and similar items in installation areas. Maintain overall continuity of color and pattern between pieces of flooring installed on covers and adjoining flooring. Tightly adhere flooring edges to substrates that abut covers and to cover perimeters.

H. Adhere resilient sheet flooring to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and

puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

I. Seamless Installation:

1. Heat-Welded Seams: Comply with ASTM F 1516. Rout joints and heat weld with welding bead to permanently fuse sections into a seamless flooring. Prepare, weld, and finish seams to produce surfaces flush with adjoining flooring surfaces.

J. Sanitary Cove Base: Install base according to manufacturer’s written instructions.

1. Heat weld seams.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting resilient sheet flooring.

B. Perform the following operations immediately after completing resilient sheet flooring installation:

1. Remove adhesive and other blemishes from surfaces.
2. Sweep and vacuum surfaces thoroughly.
3. Damp-mop surfaces to remove marks and soil.

C. Protect resilient sheet flooring from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover resilient sheet flooring until Substantial Completion.

END OF SECTION 096516

SECTION 096519 - RESILIENT TILE FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Luxury Vinyl Tile.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives[**, sealants**] [**and**] [**chemical-bonding compounds**], documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4.1: For adhesives, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Product Data for Credit IEQ 4.3: For adhesives[**and chemical-bonding compounds**], documentation including printed statement of VOC content.
4. Product Data for Credit IEQ 4.3: For resilient tile flooring, documentation from an independent testing agency indicating compliance with the FloorScore standard.
5. Laboratory Test Reports for Credit IEQ 4.3: For flooring system[**and chemical bonding compounds**], documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Samples for Verification: Full-size units of each color and pattern of floor tile required.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of floor tile to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Floor Tile: Furnish one box for every 50 boxes or fraction thereof, of each type, color, and pattern of floor tile installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for floor tile installation and seaming method indicated.

1. Engage an installer who employs workers for this Project who are trained or certified by floor tile manufacturer for installation techniques required.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store floor tile and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C). Store floor tiles on flat surfaces.

1.9 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 95 deg F (35 deg C), in spaces to receive floor tile during the following time periods:

1. 48 hours before installation.
2. During installation.
3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).

C. Close spaces to traffic during floor tile installation.

D. Close spaces to traffic for 48 hours after floor tile installation.

E. Install floor tile after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For resilient tile flooring, as determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.

1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

B. FloorScore Compliance: Resilient tile flooring shall comply with requirements of FloorScore certification.

2.2 LUXURY VINYL TILE (LVT)

A. Tile Standard: ASTM F 1700.

1. Class: Class III, printed film vinyl tile.
2. Type: B, embossed surface.

B. Thickness: 3/32 inch.

C. Size: As indicated.

D. Colors and Patterns: Custom IUH tile, match Architect’s sample.

2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by floor tile manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by floor tile and adhesive manufacturers to suit floor tile and substrate conditions indicated.

1. Adhesives shall comply with the following limits for VOC content:

a. Vinyl Composition Tile Adhesives: 50 g/L or less.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of floor tile.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to floor tile manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates: Prepare according to ASTM F 710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by floor tile manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by floor tile manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 9 pH.
4. Moisture Testing: Proceed with installation only after substrates pass testing according to floor tile manufacturer's written recommendations, but not less stringent than the following:

a. Perform anhydrous calcium chloride test according to ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.
b. Perform relative humidity test using in situ probes according to ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install floor tiles until they are the same temperature as the space where they are to be installed.

1. At least 48 hours in advance of installation, move resilient floor tile and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient floor tile.

3.3 FLOOR TILE INSTALLATION

A. Comply with manufacturer's written instructions for installing floor tile.

B. Lay out floor tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half tile at perimeter.

1. Lay tiles square with room axis.

C. Match floor tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.

1. Lay tiles with grain running in one direction.

D. Scribe, cut, and fit floor tiles to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.

E. Extend floor tiles into toe spaces, door reveals, closets, and similar openings. Extend floor tiles to center of door openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on floor tiles as marked on substrates. Use chalk or other nonpermanent marking device.

G. Install floor tiles on covers for telephone and electrical ducts, building expansion-joint covers, and similar items in finished floor areas. Maintain overall continuity of color and pattern between pieces of tile installed on covers and adjoining tiles. Tightly adhere tile edges to substrates that abut covers and to cover perimeters.

H. Adhere floor tiles to flooring substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting floor tile.

B. Perform the following operations immediately after completing floor tile installation:

1. Remove adhesive and other blemishes from exposed surfaces.
2. Sweep and vacuum surfaces thoroughly.
3. Damp-mop surfaces to remove marks and soil.

C. Protect floor tile from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Joint Sealant: Apply sealant to resilient terrazzo floor tile perimeter and around columns, at door frames, and at other joints and penetrations.

E. Cover floor tile until Substantial Completion.

END OF SECTION 096519

SECTION 096723 - RESINOUS FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes resinous flooring systems.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include manufacturer's technical data, application instructions, and recommendations for each resinous flooring component required.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.2: For liquid-applied flooring components, documentation including printed statement of VOC content.

C. Samples for Initial Selection: For each type of exposed finish required.

1.5 INFORMATIONAL SUBMITTALS

A. Installer Certificates: Signed by manufacturer certifying that installers comply with specified requirements.

B. Material Certificates: For each resinous flooring component, from manufacturer.

C. Material Test Reports: For each resinous flooring system, by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For resinous flooring to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Engage an installer who is certified in writing by resinous flooring manufacturer as qualified to apply resinous flooring systems indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating brand name and directions for storage and mixing with other components.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Comply with resinous flooring manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting resinous flooring application.

B. Lighting: Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during resinous flooring application.

C. Close spaces to traffic during resinous flooring application and for 24 hours after application unless manufacturer recommends a longer period.

PART 2 - PRODUCTS

2.1 PERORMANCE REQUIREMENTS

A. Flammability: Self-extinguishing according to ASTM D 635.

2.2 MANUFACTURERS

A. Source Limitations: Obtain primary resinous flooring materials, including primers, resins, hardening agents, grouting coats, and topcoats, from single source from single manufacturer. Obtain secondary materials, including patching and fill material, joint sealant, and repair materials, of type and from manufacturer recommended in writing by manufacturer of primary materials.

2.3 RESINOUS FLOORING

A. Resinous Flooring System: Abrasion-, impact-, and chemical-resistant, aggregate-filled, and resin-based monolithic floor surfacing designed to produce a seamless floor and integral cove base.

B. System Characteristics:

1. Color and Pattern: Match Architect's sample.
2. Wearing Surface: Orange-peel texture.
3. Overall System Thickness: 3 mils.

C. Primer: Type recommended by resinous flooring manufacturer for substrate and resinous flooring system indicated.

D. Patching and Fill Material: Resinous product of or approved by resinous flooring manufacturer and recommended by manufacturer for application indicated.

E. Topcoats: Sealing or finish coats.

1. Basis-of-Design Product: Sherwin Williams Resutile 4638 HS Polyurethane Floor Enamel, or equal by the following.

a. Dudick.
b. Stonehard.
c. Tnemec.

2. Resin: Urethane.
3. Formulation Description: High solids.
4. Type: Pigmented.
5. Number of Coats: One.
6. Thickness of Coats: 3 mils DFT.
7. Finish: Matte.

F. System Physical Properties: Provide resinous flooring system with the following minimum physical property requirements when tested according to test methods indicated:

1. DCOF: Greater than 0.42 according to ANSI A 326.3.
2. Resistance to Elevated Temperature: No slip or flow at 158° F according to MIL-D-3134J.
3. Abrasion Resistance: 63 mg maximum weight loss according to ASTM D 4060.
4. Pencil Hardness: 2H according to ASTM D 3363.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prepare and clean substrates according to resinous flooring manufacturer's written instructions for substrate indicated. Provide clean, dry substrate for resinous flooring application.

B. Concrete Substrates: Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants incompatible with resinous flooring.

1. Roughen concrete substrates as follows:

    a. Comply with manufacturer's written instructions.

2. Repair damaged and deteriorated concrete according to resinous flooring manufacturer's written instructions.
3. Verify that concrete substrates are dry and moisture-vapor emissions are within acceptable levels according to manufacturer's written instructions.

    a. Relative Humidity Test: Use in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.

4. Alkalinity and Adhesion Testing: Verify that concrete substrates have pH within acceptable range. Perform tests recommended by manufacturer. Proceed with application only after substrates pass testing.

C. Patching and Filling: Use patching and fill material to fill holes and depressions in substrates according to manufacturer's written instructions.

1. Control Joint Treatment: Treat control joints and other nonmoving substrate cracks to prevent cracks from reflecting through resinous flooring according to manufacturer's written instructions.

D. Resinous Materials: Mix components and prepare materials according to resinous flooring manufacturer's written instructions.

3.2 APPLICATION

A. Apply components of resinous flooring system according to manufacturer's written instructions to produce a uniform, monolithic wearing surface of thickness indicated.

1. Coordinate application of components to provide optimum adhesion of resinous flooring system to substrate, and optimum intercoat adhesion.

2. Cure resinous flooring components according to manufacturer's written instructions. Prevent contamination during application and curing processes.
3. Expansion and Isolation Joint Treatment: At substrate expansion and isolation joints, comply with resinous flooring manufacturer's written instructions.

B. Primer: Apply primer over prepared substrate if recommended by manufacturer.

C. Topcoats: Apply topcoats in number indicated for flooring system and at spreading rates recommended in writing by manufacturer and to produce wearing surface indicated.

3.3 PROTECTION

A. Protect resinous flooring from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by resinous flooring manufacturer.

END OF SECTION 096723

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SECTION 096813 - TILE CARPETING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes modular carpet tile.

B. Related Requirements:

1. Section 096513 "Resilient Base and Accessories" for resilient wall base and accessories installed with carpet tile.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to carpet tile installation including, but not limited to, the following:

a. Review delivery, storage, and handling procedures.
b. Review ambient conditions and ventilation procedures.
c. Review subfloor preparation procedures.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
2. Include manufacturer's written installation recommendations for each type of substrate.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.3: For flooring system elements, documentation from an independent testing agency indicating compliance with [**CRI's "Green Label Plus" testing program for carpet tile; include documentation of VOC**

concentrations for carpet tile and installation adhesives.] [**the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."**]

C. Samples for Verification: For each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.

1. Carpet Tile: Full-size Sample.
2. Exposed Edge, Transition, and Other Accessory Stripping: 12-inch- (300-mm-) long Samples.

D. Sustainable Product Certification: Provide ANSI/NSF 140 certification for carpet products.

1.5 IINFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For carpet tile, for tests performed by a qualified testing agency.

C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For carpet tiles to include in maintenance manuals. Include the following:

1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Carpet Tile: Full-size units equal to 5 percent of amount installed for each type indicated, but not less than 10 sq. yd. (8.3 sq. m).

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is certified by the International Certified Floorcovering Installers Association at the Commercial II certification level.
1. .

1.9 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI's "CRI Carpet Installation Standard."

1.10 FIELD CONDITIONS

A. Comply with CRI's "CRI Carpet Installation Standard" for temperature, humidity, and ventilation limitations.

B. Environmental Limitations: Do not deliver or install carpet tiles until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at levels planned for building occupants during the remainder of the construction period.

C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended by carpet tile manufacturer.

D. Where demountable partitions or other items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.11 WARRANTY

A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.

1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
2. Failures include, but are not limited to, the following:

a. More than 10 percent edge raveling, snags, and runs.
b. Dimensional instability.
c. Excess static discharge.
d. Loss of tuft-bind strength.
e. Loss of face fiber.
f. Delamination.

3. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CARPET TILE

A. Color: Match Architect's samples.

B. Pattern: Match Architect's samples.

C. Fiber Content: 100 percent nylon 6.

D. Pile Characteristic: Tufted Textured Loop pile.

E. Yarn Weight: 27.0 oz./cu. yd.

F. Density: 6,700 oz./cu. yd. (g/cu. cm).

G. Pile Height: 0.17 inches.

H. Pile Thickness: 0.14 inches.

I. Stitches: 10 inch (mm).

J. Primary Backing/Backcoating: Continuous filament glass fiber veil.

K. Size: 19.69 inches x 19.69 inches.

L. Applied Treatments:

1. Soil-Resistance Treatment: Manufacturer's standard treatment.
2. Antimicrobial Treatment: Manufacturer's standard treatment that protects carpet tiles as follows:

    a. Antimicrobial Activity: Not less than 2-mm halo of inhibition for gram-positive bacteria, not less than 1-mm halo of inhibition for gram-negative bacteria, and no fungal growth, according to AATCC 174.

M. Performance Characteristics:

1. Emissions: Provide carpet tile that complies with testing and product requirements of CRI's "Green Label Plus" testing program.
2. Appearance Retention Rating: Severe traffic, 3.5 minimum according to ASTM D 7330.
3. Critical Radiant Flux Classification: Not less than 0.45 W/sq. cm according to NFPA 253.
4. Dry Breaking Strength: Not less than 100 lbf (445 N) according to ASTM D 2646.
5. Tuft Bind: Not less than 10 lbf (45 N) according to ASTM D 1335.
6. Dimensional Tolerance: Within 1/32 inch (0.8 mm) of specified size dimensions, as determined by physical measurement.

7. Dimensional Stability: 0.2 percent or less according to ISO 2551 (Aachen Test).
8. Colorfastness to Crocking: Not less than 4, wet and dry, according to AATCC 165.
9. Colorfastness to Light: Not less than 4 after 60 AFU (AATCC fading units) according to AATCC 16, Option E.
10. Electrostatic Propensity: Less than 3.5 kV according to AATCC 134.

2.2 INSTALLATION ACCESSORIES

A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.

B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive type to suit products and subfloor conditions indicated, that comply with flammability requirements for installed carpet tile, and are recommended by carpet tile manufacturer for releasable installation.

1. VOC Content: 50 g/L or less.

C. Metal Edge/Transition Strips: Extruded aluminum with mill finish of profile and width shown, of height required to protect exposed edge of carpet, and of maximum lengths to minimize running joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance.

B. Examine carpet tile for type, color, pattern, and potential defects.

C. Concrete Slabs: Verify that finishes comply with requirements specified in Section 033000 "Cast-in-Place Concrete" and that surfaces are free of cracks, ridges, depressions, scale, and foreign deposits.

1. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.

a. Anhydrous Calcium Chloride Test: ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.

b. Relative Humidity Test: Using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
c. Perform additional moisture tests recommended in writing by adhesive and carpet tile manufacturers. Proceed with installation only after substrates pass testing.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General: Comply with CRI's "CRI Carpet Installation Standards" and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile.

B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch (3 mm) wide or wider, and protrusions more than 1/32 inch (0.8 mm) unless more stringent requirements are required by manufacturer's written instructions.

C. Concrete Substrates: Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by adhesive and carpet tile manufacturers.

D. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.3 INSTALLATION

A. General: Comply with CRI's "CRI Carpet Installation Standard," Section 18, "Modular Carpet" and with carpet tile manufacturer's written installation instructions.

B. Installation Method: Glue down; install every tile with full-spread, releasable, pressure-sensitive adhesive.

C. Maintain dye-lot integrity. Do not mix dye lots in same area.

D. Maintain pile-direction patterns recommended in writing by carpet tile manufacturer.

E. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.

F. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

G. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on carpet tile as marked on subfloor. Use nonpermanent, nonstaining marking device.

H. Install pattern parallel to walls and borders.

I. Access Flooring: Stagger joints of carpet tiles so carpet tile grid is offset from access flooring panel grid. Do not fill seams of access flooring panels with carpet adhesive; keep seams free of adhesive.

3.4 CLEANING AND PROTECTION

A. Perform the following operations immediately after installing carpet tile:

1. Remove excess adhesive and other surface blemishes using cleaner recommended by carpet tile manufacturer.
2. Remove yarns that protrude from carpet tile surface.
3. Vacuum carpet tile using commercial machine with face-beater element.

B. Protect installed carpet tile to comply with CRI's "CRI Carpet Installation Standard," Section 20, "Protecting Indoor Installations."

C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION 096813

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SECTION 099123 - INTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on interior substrates.

1.3 DEFINITIONS

A. MPI Gloss Level 1: Not more than five units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523.

B. MPI Gloss Level 2: Not more than 10 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

C. MPI Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

D. MPI Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D 523.

E. MPI Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523.

F. MPI Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523.

G. MPI Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

B. LEED Submittals:

1. Product Data for Credit EQ 4.2: For paints and coatings, documentation including printed statement of VOC content.

C. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.

1. Submit Samples on rigid backing, 8 inches (200 mm) square.
2. Apply coats on Samples in steps to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

D. Product List: Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include color designations.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Paint: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.6 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Architect will select one surface to represent surfaces and conditions for application of each paint system.

a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
b. Other Items: Architect will designate items or areas required.

2. Final approval of color selections will be based on mockups.

a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).

1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).

B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Sherwin Williams Company.

B. Products: Subject to compliance with requirements, provide product listed in the Interior Painting Schedule for the paint category indicated.

2.2 PAINT, GENERAL

A. MPI Standards: Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products Lists."

B. Material Compatibility:

1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

C. VOC Content: Products shall comply with VOC limits of authorities having jurisdiction and, for interior paints and coatings applied at Project site, the following VOC limits, exclusive of colorants added to a tint base:

1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 150 g/L.
3. Dry-Fog Coatings: 400 g/L.

4. Primers, Sealers, and Undercoaters: 200 g/L.
5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
6. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
7. Pretreatment Wash Primers: 420 g/L.
8. Floor Coatings: 100 g/L.
9. Shellacs, Clear: 730 g/L.
10. Shellacs, Pigmented: 550 g/L.

D. Colors: As indicated in Finish Legend.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:

1. Concrete: 12 percent.
2. Fiber-Cement Board: 12 percent.
3. Masonry (Clay and CMUs): 12 percent.
4. Wood: 15 percent.
5. Gypsum Board: 12 percent.
6. Plaster: 12 percent.

C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

D. Plaster Substrates: Verify that plaster is fully cured.

E. Spray-Textured Ceiling Substrates: Verify that surfaces are dry.

F. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

G. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" and “MPI Maintenance Repainting Manual” applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceeds that permitted in manufacturer's written instructions.

F. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer.

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

I. Aluminum Substrates:

1. General: Remove all loose paint by scraping, sanding and/or power tool cleaning. Scuff sand all bare aluminum and remaining existing paint to create a surface profile. Clean all surfaces to be painted.

a. Wash/clean all surfaces to be painted to remove all dirt, grease and surface contaminates.
b. Sand the existing paint finish and all bare aluminum thoroughly to create a profile so the new coating can obtain proper adhesion.

c. If the surfaces to be painted are heavily contaminated with grease or oil, clean the highly contaminated areas with Great Lakes Laboratories Extra Muscle Prepaint Cleaner.
d. Remove all loose existing paint by using SSPC-SP2 Hand Tool Cleaning and SSPC-SP3 Power Tool Cleaning.
e. Follow all instructions on the Product Data Sheet and Product Label.
f. Apply a “Mock-up Area” to insure successful adhesion before the start of the project.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."

1. Use applicators and techniques suited for paint and substrate indicated.
2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:

1. Paint the following work where exposed in occupied spaces:

a. Equipment, including panelboards.
b. Uninsulated metal piping.
c. Uninsulated plastic piping.
d. Pipe hangers and supports.
e. Metal conduit.
f. Plastic conduit.

g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
h. Other items as directed by Architect.

2. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.

1. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 Interior Paint Schedule

A. CMU Substrates:

1. Institutional Low-Odor/VOC Acrylic-Alkyd System:

a. Block Filler: Block filler, latex, interior/exterior-on previously unfinished surfaces.

1) SW Loxon Block Surfacer.

b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.

c. Topcoat: Acrylic Alkyd, interior, institutional low odor/VOC, eggshell (MPI Gloss Level 4).

1) SW Promar 200 Interior Waterbased Acrylic-Alkyd Enamel.

B. Steel Substrates:

1. Institutional Low-Odor/VOC Acrylic-Alkyd System.

a. Prime Coat: Primer, water based.

1) SW Procryl Acrylic Primer for spot priming of pre-primed surfaces.

b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.

c. Topcoat: Acrylic-Alkyd, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5).

1) SW Promar 200 Interior Waterbased Acrylic-Alkyd Enamel.

C. Aluminum Substrates:

1. Water-Based Light Industrial Coating System:

a. Prime Coat: Primer, quick dry epoxy, for aluminum.

1) SW Macropoxy 646-100, Low-VOC, Fast Cure Epoxy B58W620.

b. Topcoat: Light industrial coating, interior, water based (MPI Gloss Level 6).

1) SW Waterbased Acrolon 100 Polyurethane, B65W721.

D. Copper Substrates

1. Institutional Low-Odor/VOC Acrylic-Alkyd System:

a. Prime Coat: Primer, water based.

1) SW Procryl Acrylic Primer.

b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.

c. Topcoat: Acrylic-Alkyd, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5).

1) SW Promar 200 Interior Water Based Acrylic Alkyd Enamel.

E. Gypsum Board and Plaster Substrates:

1. Institutional Low-Odor/VOC Acrylic-Alkyd System:

a. Prime Coat: Primer sealer, interior, institutional low odor/VOC.

1) SW Promar 200 Zero VOC Latex Primer.

b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.

c. Topcoat: Acrylic-Alkyd, interior, institutional low odor/VOC, eggshell (MPI Gloss Level 4).

1) SW Promar 200 Interior Waterbased Acrylic-Alkyd Enamel.

d. Topcoat: Acrylic-Alkyd, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5).

1) SW Promar 200 Interior Waterbased Acrylic-Alkyd Enamel.

END OF SECTION 099123

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SECTION 102800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Toilet Room accessories.
2. Public Use Shower Room accessories.
3. Custodial accessories.

1.3 COORDINATION

A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.

B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.

B. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.

1. Identify locations using room designations indicated.
2. Identify accessories using designations indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For accessories to include in maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Special Warranty for Mirrors: Manufacturer agrees to repair or replace mirrors that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, visible silver spoilage defects.
2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TOILET ROOM ACCESSORIES

A. Source Limitations: Obtain public-use washroom accessories from single source from single manufacturer.

1. Bradley Corporation.
2. American Specialties, Inc.

B. Toilet Tissue (Roll) Dispenser:

1. Description: Roll-in-reserve dispenser with hinged front secured with tumbler lockset.
2. Mounting: Surface mounted.
3. Operation: Noncontrol delivery with theft-resistant spindle.
4. Capacity: Designed for 4-1/2- or 5-inch- (114- or 127-mm-) diameter tissue rolls.
5. Material and Finish: Stainless steel, No. 4 finish (satin).

C. Paper Towel (Roll) Dispenser:

1. Description: Lever-actuated mechanism permitting controlled delivery of paper rolls in preset lengths per stroke.
2. Mounting: Surface mounted.
3. Minimum Capacity: 8-inch- (203-mm-) wide, 800-foot- (244-m-) long roll.
4. Material and Finish: Stainless steel, No. 4 finish (satin).
5. Lockset: Tumbler type.

D. Waste Receptacle:

1. Mounting: Freestanding.
2. Minimum Capacity: 13 gal.
3. Material and Finish: Stainless steel, No. 4 finish (satin).
4. Liner: Reusable vinyl liner.

E. Liquid-Soap Dispenser:

1. Description: Designed for dispensing antibacterial soap in liquid or lotion form.
2. Mounting: Vertically oriented, surface mounted.
3. Capacity: 40 oz. (mL).
4. Materials: Stainless Steel tank.
5. Lockset: Tumbler type.

F. Grab Bar:

1. Mounting: Flanges with concealed fasteners.
2. Material: Stainless steel, 0.05 inch (1.3 mm) thick.

    a. Finish: Smooth, No. 4 finish (satin) on ends and slip-resistant texture in grip area.

3. Outside Diameter: 1-1/2 inches (38 mm).
4. Configuration and Length: As indicated on Drawings.

G. Mirror Unit:

1. Frame: Stainless-steel angle, 0.05 inch (1.3 mm) thick.

    a. Corners: Welded and ground smooth.

2. Integral Shelf: 5 inches (127 mm) deep.
3. Hangers: Produce rigid, tamper- and theft-resistant installation, using method indicated below.

    a. One-piece, galvanized-steel, wall-hanger device with spring-action locking mechanism to hold mirror unit in position with no exposed screws or bolts.
    b. Wall bracket of galvanized steel, equipped with concealed locking devices requiring a special tool to remove.

4. Size: As indicated on Drawings.

H. Coat Hook:

1. Description: Single-prong unit.
2. Material and Finish: Stainless steel, No. 4 finish (satin).

2.2 PUBLIC-USE SHOWER ROOM ACCESSORIES

A. Source Limitations: Obtain public-use shower room accessories from single source from single manufacturer.

B. Shower Curtain Rod:

1. Description: 1-1/4-inch (32-mm) OD; fabricated from nominal 0.05-inch- (1.3-mm-) thick stainless steel.
2. Mounting Flanges: Stainless-steel flanges designed for exposed fasteners.
3. Finish: [Stainless steel, No. 4 finish (satin).

C. Shower Curtain:

1. Size: Minimum 6 inches (152 mm) wider than opening by 72 inches (1828 mm) high.
2. Material: Duck, minimum 8 oz. (227 g), white, 100 percent cotton.
3. Color: As selected from manufacturer's full range.
4. Grommets: Corrosion resistant at minimum 6 inches (152 mm) o.c. through top hem.
5. Shower Curtain Hooks: Stainless-steel, spring wire curtain hooks with snap fasteners, sized to accommodate specified curtain rod. Provide one hook per curtain grommet.

D. Folding Shower Seat:

1. Configuration: L-shaped seat, designed for wheelchair access.
2. Seat: Phenolic or polymeric composite of slat-type or one-piece construction in color as selected by Architect.
3. Mounting Mechanism: Stainless steel, No. 4 finish (satin).

E. Shower Shelf:

1. Description: 12 inch long x 4 inches wide with exposed edges turned down but not less than ½ inch and supported by two brackets, integral with shelf.
2. Mounting: Surface mounted.
3. Material and Finish: Stainless steel, No. 4 finish (satin).

2.3 CUSTODIAL ACCESSORIES

A. Source Limitations: Obtain custodial accessories from single source from single manufacturer.

B. Mop and Broom Holder:

1. Description: Unit with shelf, hooks, holders, and rod suspended beneath shelf.
2. Length: 36 inches (914 mm).
3. Hooks: Four.

4. Mop/Broom Holders: Three, spring-loaded, rubber hat, cam type.
5. Material and Finish: Stainless steel, No. 4 finish (satin).

    a. Shelf: Not less than nominal 0.05-inch- (1.3-mm-) thick stainless steel.
    b. Rod: Approximately 1/4-inch- (6-mm-) diameter stainless steel.

2.4 MATERIALS

A. Stainless Steel: ASTM A 666, Type 304, 0.031-inch (0.8-mm) minimum nominal thickness unless otherwise indicated.

B. Brass: ASTM B 19, flat products; ASTM B 16/B 16M, rods, shapes, forgings, and flat products with finished edges; or ASTM B 30, castings.

C. Steel Sheet: ASTM A 1008/A 1008M, Designation CS (cold rolled, commercial steel), 0.036-inch (0.9-mm) minimum nominal thickness.

D. Galvanized-Steel Sheet: ASTM A 653/A 653M, with G60 (Z180) hot-dip zinc coating.

E. Galvanized-Steel Mounting Devices: ASTM A 153/A 153M, hot-dip galvanized after fabrication.

F. Fasteners: Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.

G. Mirrors: ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.5 FABRICATION

A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.

B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Grab Bars: Install to withstand a downward load of at least 250 lbf (1112 N), when tested according to ASTM F 446.

3.2 ADJUSTING AND CLEANING

A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.

B. Remove temporary labels and protective coatings.

C. Clean and polish exposed surfaces according to manufacturer's written instructions.

END OF SECTION 102800

SECTION 104413 - FIRE PROTECTION CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fire protection cabinets for the following:

a. Portable fire extinguishers.

B. Related Sections:

1. Division 01 Section “Sustainable Design Requirements – LEED for New Construction and Major Renovations” for requirements.
2. Division 10 Section "Fire Extinguishers."

1.3 SUBMITTALS

A. LEED Submittals:

1. Product Data for Credit: Indicating percentages by weight of postconsumer and preconsumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.

B. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for fire protection cabinets.

1. Fire Protection Cabinets: Include roughing-in dimensions, details showing mounting methods, relationships of box and trim to surrounding construction, door hardware, cabinet type, trim style, and panel style.

C. Shop Drawings: For fire protection cabinets. Include plans, elevations, sections, details, and attachments to other work.

D. Product Schedule: For fire protection cabinets. Coordinate final fire protection cabinet schedule with fire extinguisher schedule to ensure proper fit and function. Use same designations indicated on Drawings.

E. Maintenance Data: For fire protection cabinets to include in maintenance manuals.

1.5 COORDINATION

A. Coordinate size of fire protection cabinets to ensure that type and capacity of fire extinguishers indicated are accommodated.

B. Coordinate sizes and locations of fire protection cabinets with wall depths.

1.6 SEQUENCING

A. Apply decals on field-painted, fire protection cabinets after painting is complete.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.
B. Stainless-Steel Sheet: ASTM A 666, Type 304.

2.2 FIRE PROTECTION CABINET

A. Cabinet Type 1: Suitable for fire extinguisher.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. J. L. Industries, Inc., a division of Activar Construction Products Group;
b. Larsen's Manufacturing Company; Basis of Design: Larsen B2409-R2, recessed fire extinguisher cabinet.

B. Cabinet Construction: Non-rated, Rated where indicated in fire-rated partitions per drawings.

1. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls lined with minimum 5/8-inch- thick, fire-barrier material.

C. Cabinet Material: 0.068-inch- thick, steel sheet.

D. Recessed Cabinet: Cabinet box recessed in walls of sufficient depth to suit style of trim indicated.

1. Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend) of ¼" to 5/16".

E. Semi-Recessed Cabinet:

1. One piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge.

a. Square-Edge trim 1 ¼ backbend depth.

F. Cabinet Trim Material: Cold rolled sheet steel with square trim for recessed cabinet.

G. Door Material: Cold rolled sheet steel.

H. Door Style: Framed full glass panel with tempered glass.

I. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated, and as follows:

1. Standard door pull.
2. Continuous Hinge: Same material and finish as trim, permitting door to open 180 degrees.

J. Accessories:

1. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to security fire protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.

K. Finishes:

1. Factory painted finish, as selected by Architect.

2.3 FABRICATION

A. Fire Protection Cabinets: Provide manufacturer's standard box (tub) with trim, frame, door, and hardware to suit cabinet type, trim style, and door style indicated.

1. Weld joints and grind smooth.
2. Provide factory-drilled mounting holes.

B. Cabinet Doors: Fabricate doors according to manufacturer's standards, from materials indicated and coordinated with cabinet types and trim styles selected.

1. Fabricate door frames of one-piece construction with edges flanged.
2. Miter and weld perimeter door frames.

C. Cabinet Trim: Fabricate cabinet trim in one piece with corners mitered, welded, and ground smooth.

2.4 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces of fire protection cabinets from damage by applying a strippable, temporary protective covering before shipping.

C. Finish fire protection cabinets after assembly.

D. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls and partitions for suitable framing depth and blocking where cabinets will be installed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare recesses for recessed fire protection cabinets as required by type and size of cabinet and trim style.

3.3 INSTALLATION

A. General: Install fire protection cabinets in locations and at mounting heights indicated or, if not indicated, at heights acceptable to authorities having jurisdiction.

B. Fire Protection Cabinets: Fasten cabinets to structure, square and plumb.

1. Unless otherwise indicated, provide recessed fire protection cabinets. If wall thickness is not adequate for recessed cabinets, provide semirecessed fire protection cabinets.

2. Fasten mounting brackets to inside surface of fire protection cabinets, square and plumb.

3. Fire-Rated Cabinets:

   a. Install cabinet with not more than 1/16 inch tolerance between pipe OD and knockout
      OD. Center pipe within knockout.
   b. Seal through penetrations with firestopping sealant as specifid in Section 078413 “Penetration Firestopping”.

3.4 ADJUSTING AND CLEANING

A. Remove temporary protective coverings and strippable films, if any, as fire protection cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.

B. Adjust fire protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.

C. On completion of fire protection cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.

D. Touch up marred finishes, or replace fire protection cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by fire protection cabinet and mounting bracket manufacturers.

E. Replace fire protection cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 104413

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SECTION 104416 - FIRE EXTINGUISHERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

B. Related Sections:

1. Division 01 Section “Sustainable Design Requirements – LEED for Commercial Interiors” for compliance requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rating and classification, material descriptions, dimensions of individual components and profiles, and finishes for fire extinguisher and mounting brackets.

B. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."

B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.

1. Provide fire extinguishers approved, listed, and labeled by FMG.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Failure of hydrostatic test according to NFPA 10.

b. Faulty operation of valves or release levers.

2. Warranty Period: Six (6) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

A. Fire Extinguishers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Amerex Corporation.

2. Valves: Manufacturer's standard.
3. Handles and Levers: Manufacturer's standard.
4. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B and bar coding for documenting fire extinguisher location, inspections, maintenance, and recharging.

B. Multipurpose Dry-Chemical Type in Steel Container 4-A:60-B:C,10-lb nominal capacity, with monoammonium phosphate-based dry chemical in enameled-steel container.

C. Carbon Dioxide Type: UL rated 10-B: C, 15 lb nominal capacity with carbon dioxide in manufacturer’s standard enamel-metal container.

2.2 MOUNTING BRACKETS

A. Mounting Brackets: Manufacturer's standard galvanized steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Amerex Corporation.

B. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as indicated by Architect.

1. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.

a. Orientation: Vertical.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fire extinguishers for proper charging and tagging.

1. Remove and replace damaged, defective, or undercharged fire extinguishers.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction. Coordinate final locations with Laboratory equipment, Architect, and authorities having jurisdiction.

1. Mounting Brackets: 48 inches above finished floor to top of fire extinguisher, U.N.O.

END OF SECTION 104416

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SECTION 105113 - METAL LOCKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Heavy-duty metal lockers.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of metal locker.

B. Shop Drawings: For metal lockers. Include plans, elevations, sections, details, and attachments to other work.

1. Show locker trim and accessories.
2. Include locker identification system and numbering sequence.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Qualification Data: For qualified Installer.

E. Maintenance Data: For adjusting, repairing, and replacing locker doors and latching mechanisms to include in maintenance manuals.

F. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain metal lockers and accessories from single source from single manufacturer.

C. Regulatory Requirements: Where metal lockers are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver metal lockers until spaces to receive them are clean, dry, and ready for their installation.

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify actual dimensions of recessed openings by field measurements before fabrication.

1.7 COORDINATION

A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of work specified in other Sections to ensure that metal lockers can be supported and installed as indicated.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal lockers that fail in materials or workmanship, excluding finish, within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures.
    b. Faulty operation of latches and other door hardware.

2. Damage from deliberate destruction and vandalism is excluded.
3. Warranty Period for All-Welded Metal Lockers: Lifetime from date of Substantial Completion.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Full-size units of the following metal locker hardware items equal to 25 percent of amount installed for each type and finish installed, but no fewer than five units:

a. Identification plates.
b. Hooks.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.

B. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with A60 (ZF180) zinc-iron, alloy (galvannealed) coating designation.

C. Expanded Metal: ASTM F 1267, Type II (flattened), Class I, 3/4-inch (19-mm) steel mesh, with at least 70 percent open area.

D. Extruded Aluminum: ASTM B 221 (ASTM B 221M), alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated.

E. Steel Tube: ASTM A 500, cold rolled.

F. Fasteners: Zinc- or nickel-plated steel, slotless-type, exposed bolt heads; with self-locking nuts or lock washers for nuts on moving parts.

G. Anchors: Material, type, and size required for secure anchorage to each substrate.

1. Provide nonferrous-metal or hot-dip galvanized anchors and inserts on inside face of exterior walls, and elsewhere as indicated, for corrosion resistance.
2. Provide toothed-steel or lead expansion sleeves for drilled-in-place anchors.

2.2 HEAVY-DUTY METAL LOCKERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. DeBourgh Mfg. Co.; Sentry Corridor/Personnel Lockers.
2. Lockers MFG.
3. Lyon Workspace Products, LLC; All-Welded Lockers.
4. Penco Products, Inc.; All-Welded Lockers.

B. Locker Arrangement: As indicated on Drawings.

C. Material: Cold-rolled steel sheet.

D. Body: Assembled by welding body components together. Fabricate from unperforated steel sheet with thicknesses as follows:

1. Tops, Bottoms, and Sides: 0.060-inch (1.52-mm) nominal thickness.
2. Backs: 0.048-inch (1.21-mm) nominal thickness.
3. Shelves: 0.060-inch (1.52-mm) nominal thickness, with double bend at front and single bend at sides and back.

E. Frames: Channel formed; fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet; lapped and factory welded at corners; with top and bottom main frames factory welded into vertical main frames. Form continuous, integral door strike full height on vertical main frames.

1. Cross Frames between Tiers: Channel formed and fabricated from same material as main frames; welded to vertical main frames.

F. Doors: One piece; fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet; formed into channel shape with double bend at vertical edges and with right-angle single bend at horizontal edges.

1. Reinforcement: Manufacturer's standard reinforcing angles, channels, or stiffeners for doors more than 15 inches (381 mm) wide; welded to inner face of doors.
2. Door Style:

a. Louvered Vents: No fewer than six louver openings at top and bottom for single-tier three louver openings at top and bottom for double-tier two louver openings at top and bottom, or three louver openings at top or bottom, for triple-tier lockers.
b. Security Vents: Manufacturer's standard, stamped horizontal or vertical.

G. Hinges: Welded to door and attached to door frame with no fewer than two factory-installed rivets per hinge that are completely concealed and tamper resistant when door is closed; fabricated to swing 180 degrees.

1. Continuous Hinges: Manufacturer's standard, steel, full height.

H. Recessed Door Handle and Latch: Stainless-steel cup with integral door pull, recessed so locking device does not protrude beyond face of door; pry and vandal resistant.

1. Multipoint Latching: Finger-lift latch control designed for use with built-in combination locks or padlocks; positive automatic latching and prelocking.

a. Latch Hooks: Equip doors 48 inches (1219 mm) and higher with three latch hooks and doors less than 48 inches (1219 mm) high with two latch hooks; fabricated from 0.120-inch (3.04-mm) nominal-thickness steel sheet; welded to full-height door strikes; with resilient silencer on each latch hook.
b. Latching Mechanism: Manufacturer's standard, rattle-free latching mechanism and moving components isolated to prevent metal-to-metal contact, and incorporating

a prelocking device that allows locker door to be locked while door is open and then closed without unlocking or damaging lock or latching mechanism.

I. Equipment: Equip each metal locker with identification plate and the following unless otherwise indicated:

1. Single-Tier Units: Shelf, one double-prong ceiling hook, and two single-prong wall hooks.
2. Metal Z Base, 4” High.

J. Accessories:

1. Continuous Sloping Tops: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet, with a pitch of approximately 20 degrees.

a. Closures: Vertical-end type.

2. Recess Trim: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
3. Filler Panels: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
4. Boxed End Panels: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.

K. Finish: Baked enamel.

1. Color(s): As selected by Architect from manufacturer's full range.

2.3 FABRICATION

A. Fabricate metal lockers square, rigid, and without warp and with metal faces flat and free of dents or distortion. Make exposed metal edges safe to touch and free of sharp edges and burrs.

1. Form body panels, doors, shelves, and accessories from one-piece steel sheet unless otherwise indicated.
2. Provide fasteners, filler plates, supports, clips, and closures as required for complete installation.

B. Fabricate each metal locker with an individual door and frame; individual top, bottom, and back; and common intermediate uprights separating compartments. Factory weld frame members of each metal locker together to form a rigid, one-piece assembly.

C. All-Welded Construction: Factory preassemble metal lockers by welding all joints, seams, and connections; with no bolts, nuts, screws, or rivets used in assembly of main locker groups. Factory weld main locker groups into one-piece structures. Grind exposed welds flush.

D. Accessible Lockers: Fabricate as follows:

1. Locate bottom shelf no lower than 15 inches (381 mm) above the floor.
2. Where hooks, coat rods, or additional shelves are provided, locate no higher than 48 inches (1219 mm) above the floor.

E. Hooks: Manufacturer's standard ball-pointed type, aluminum or steel; zinc plated.

F. Coat Rods: Fabricated from 3/4-inch- (19-mm-) diameter steel, chrome finished.

G. Identification Plates: Manufacturer's standard, etched, embossed, or stamped aluminum plates, with numbers and letters at least 3/8 inch (9 mm) high.

H. Continuous Sloping Tops: Fabricated in lengths as long as practical, without visible fasteners at splice locations; finished to match lockers.

1. Sloping-top corner fillers, mitered.

I. Recess Trim: Fabricated with minimum 2-1/2-inch (64-mm) face width and in lengths as long as practical; finished to match lockers.

J. Filler Panels: Fabricated in an unequal leg angle shape; finished to match lockers. Provide slip-joint filler angle formed to receive filler panel.

1. Provide one-piece panels for double-row (back-to-back) locker ends.

K. Continuous Zee Base: Fabricated from manufacturer’s standard thickness, but not less than 0.060 inch nominal thickness sheet steel. Height: 4 inches.

2.4 STEEL SHEET FINISHES

A. Factory finish steel surfaces and accessories except stainless-steel and chrome-plated surfaces.

B. Baked-Enamel Finish: Immediately after cleaning, pretreating, and phosphatizing, apply manufacturer's standard thermosetting baked-enamel finish. Comply with paint manufacturer's written instructions for application, baking, and minimum dry film thickness.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, and support bases, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install level, plumb, and true; shim as required, using concealed shims.

1. Anchor locker runs at ends and at intervals recommended by manufacturer, but not more than 36 inches (910 mm) o.c. Using concealed fasteners, install anchors through backup reinforcing plates, channels, or blocking as required to prevent metal distortion.
2. Anchor single rows of metal lockers to walls near top and bottom of lockers.
3. Anchor back-to-back metal lockers to floor.

B. All-Welded Metal Lockers: Connect groups together with standard fasteners, with no exposed fasteners on face frames.

C. Equipment and Accessories: Fit exposed connections of trim, fillers, and closures accurately together to form tight, hairline joints, with concealed fasteners and splice plates.

1. Attach hooks with at least two fasteners.
2. Attach door locks on doors using security-type fasteners.
3. Identification Plates: Identify metal lockers with identification indicated on Drawings.

    a. Attach plates to each locker door, near top, centered, with at least two aluminum rivets.

4. Attach recess trim to recessed metal lockers with concealed clips.
5. Attach filler panels with concealed fasteners. Locate filler panels where indicated on Drawings.
6. Attach sloping-top units to metal lockers, with closures at exposed ends.
7. Attach boxed end panels with concealed fasteners to conceal exposed ends of nonrecessed metal lockers.
8. Attach finished end panels with fasteners only at perimeter to conceal exposed ends of nonrecessed metal lockers.

3.3 ADJUSTING, CLEANING, AND PROTECTION

A. Clean, lubricate, and adjust hardware. Adjust doors and latches to operate easily without binding. Verify that integral locking devices operate properly.

B. Protect metal lockers from damage, abuse, dust, dirt, stain, or paint. Do not permit use during construction.

C. Touch up marred finishes or replace metal lockers that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by locker manufacturer.

END OF SECTION 105113

SECTION 122413 - ROLLER WINDOW SHADES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manually operated roller shades with single and double rollers.

B. Related Requirements:

1. Section 061053 "Miscellaneous Rough Carpentry" for wood blocking and grounds for mounting roller shades and accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include styles, material descriptions, construction details, dimensions of individual components and profiles, features, finishes, and operating instructions for roller shades.

B. Shop Drawings: Show fabrication and installation details for roller shades, including shadeband materials, their orientation to rollers, and their seam and batten locations.

C. Samples for Initial Selection: For each type and color of shadeband material.

1. Include Samples of accessories involving color selection.

D. Roller-Shade Schedule: Use same designations indicated on Drawings.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roller shades to include in maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver roller shades in factory packages, marked with manufacturer, product name, and location of installation using same designations indicated on Drawings.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not install roller shades until construction and finish work in spaces, including painting, is complete and dry and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

B. Field Measurements: Where roller shades are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Allow clearances for operating hardware of operable glazed units through entire operating range. Notify Architect of installation conditions that vary from Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers subject to compliance with requirements, provide products by one of the following:

1. MechoShade Systems, Inc.
2. Draper, Inc.

B. Source Limitations: Obtain roller shades from single source from single manufacturer.

C. Installation Accessories:

1. Front Fascia: Aluminum extrusion that conceals front and underside of roller and operating mechanism and attaches to roller endcaps without exposed fasteners.

a. Shape: L-shaped.
b. Height: Manufacturer's standard height required to conceal roller and shadeband when shade is fully open.

2. Endcap Covers: To cover exposed endcaps.
3. Installation Accessories Color and Finish: As selected from manufacturer's full range.

2.2 MANUALLY OPERATED SHADES WITH SINGLE ROLLERS

A. Chain-and-Clutch Operating Mechanisms: With continuous-loop bead chain and clutch that stops shade movement when bead chain is released; permanently adjusted and lubricated.

1. Bead Chains: Stainless steel.

a. Loop Length: Full length of roller shade.
b. Limit Stops: Provide upper and lower ball stops.

2. Spring Lift-Assist Mechanisms: Manufacturer's standard for balancing roller-shade weight and lifting heavy roller shades.

a. Provide for shadebands that weigh more than 10 lb (4.5 kg) or for shades as recommended by manufacturer, whichever criteria are more stringent.

B. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.

1. Roller Drive-End Location: Jamb side of each unit left or right as condition dictates.
2. Direction of Shadeband Roll: Regular, from back of roller.
3. Shadeband-to-Roller Attachment: Removable spline fitting integral channel in tube.

C. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.

D. Roller-Coupling Assemblies: Coordinated with operating mechanism and designed to join up to three inline rollers into a multiband shade that is operated by one roller drive-end assembly.

E. Shadebands:

1. Shadeband Material: Light-filtering fabric.
2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.

a. Type: Enclosed in sealed pocket of shadeband material.

F. Installation Accessories:

1. Front Fascia: Aluminum extrusion that conceals front and underside of roller and operating mechanism and attaches to roller endcaps without exposed fasteners.

a. Shape: L-shaped.
b. Height: Manufacturer's standard height required to conceal roller and shadeband when shade is fully open.

2. Endcap Covers: To cover exposed endcaps.
3. Installation Accessories Color and Finish: As selected from manufacturer's full range.

2.3 SHADEBAND MATERIALS

A. Shadeband Material Flame-Resistance Rating: Comply with NFPA 701. Testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Light-Filtering Fabric: Woven fabric, stain and fade resistant.

1. Source: Roller-shade manufacturer.
2. Type: Vinyl coated polyester.
3. Weave: Basketweave.
4. Thickness: 0.032inch minimum.
5. Roll Width: Match window width.
6. Orientation on Shadeband: Non-Railroaded.
7. Openness Factor: 5 percent.
8. Color: As indicated on Drawings.

2.4 ROLLER-SHADE FABRICATION

A. Product Safety Standard: Fabricate roller shades to comply with WCMA A 100.1, including requirements for flexible, chain-loop devices; lead content of components; and warning labels.

B. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F (23 deg C):

1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which shade is installed less 1/4 inch (6 mm) per side or 1/2-inch (13-mm) total, plus or minus 1/8 inch (3.1 mm). Length equal to head-to-sill or -floor dimension of opening in which shade is installed less 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm).

C. Shadeband Fabrication: Fabricate shadebands without battens or seams to extent possible except as follows:

1. Vertical Shades: Where width-to-length ratio of shadeband is equal to or greater than 1:4, provide battens and seams at uniform spacings along shadeband length to ensure shadeband tracking and alignment through its full range of

movement without distortion of the material, aligning battens and seams with window framing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, operational clearances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ROLLER-SHADE INSTALLATION

A. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions.

3.3 ADJUSTING

A. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.

3.4 CLEANING AND PROTECTION

A. Clean roller-shade surfaces after installation, according to manufacturer's written instructions.

B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that roller shades are without damage or deterioration at time of Substantial Completion.

C. Replace damaged roller shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain roller shades.

END OF SECTION 122413

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SECTION 123661 - SIMULATED STONE COUNTERTOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Solid-surface-material countertops, backsplashes, and shower surrounds.

1.3 ACTION SUBMITTALS

A. Product Data: For countertop materials and sinks.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
2. Product Data for Credit IEQ 4.4: For adhesives and composite wood products, documentation indicating that product contains no urea formaldehyde.

C. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.

D. Samples for Verification: For the following products:

1. Countertop and shower surround material, 6 inches (150 mm) square.

1.4 PROJECT CONDITIONS

A. Field Measurements: Verify dimensions of countertops by field measurements after base cabinets are installed but before countertop fabrication is complete.

1.5 COORDINATION

A. Coordinate locations of utilities that will penetrate countertops or backsplashes.

PART 2 - PRODUCTS

2.1 SOLID-SURFACE-MATERIAL COUNTERTOPS

A. Configuration: Provide countertops with the following front and backsplash style:

1. Front: Straight, slightly eased at top.
2. Backsplash: Straight, slightly eased at corner.
3. Endsplash: Matching backsplash where indicated.

B. Countertops: 1/2-inch- (12.7-mm-) thick, solid surface material with front edge built up with same material.

C. Backsplashes: 1/2-inch- (12.7-mm-) thick, solid surface material.

D. Fabrication: Fabricate tops in one piece with shop-applied edges unless otherwise indicated. Comply with solid-surface-material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.

1. Fabricate with loose backsplashes for field assembly.
2. Install integral sink bowls in countertops in the shop.

2.2 COUNTERTOP MATERIALS

A. Adhesives: Adhesives shall not contain urea formaldehyde.

B. Solid Surface Material: Homogeneous solid sheets of filled plastic resin complying with ANSI SS1.

1. Type: Provide Standard Type unless Special Purpose Type is indicated.
2. Colors and Patterns: Match Architect's samples.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install countertops level to a tolerance of 1/8 inch in 8 feet (3 mm in 2.4 m).

B. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Pre-drill holes for screws as recommended by manufacturer. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with

manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.

1. Install backsplashes and endsplashes to comply with manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
2. Seal edges of cutouts in particleboard subtops by saturating with varnish.

END OF SECTION 123661

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SECTION 142100 - ELECTRIC TRACTION ELEVATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes electric traction service elevators.

B. Related Requirements:

1. Section 042000 "Unit Masonry" for setting sleeves, inserts, and anchoring devices in masonry and for grouting elevator entrance frames installed in masonry walls.

2. Section 055000 "Metal Fabrications" for the following:

    a. Attachment plates and angle brackets for supporting guide-rail brackets.
    b. Hoist beams.
    c. Structural-steel shapes for subsills.
    d. Pit ladders.

3. Section 096519 Resilient Tile Flooring for finish flooring in elevator cars.
4. Section 271500 "Communications Horizontal Cabling" for telephone service for elevators and for Internet connection to elevator controllers for remote monitoring of elevator performance.
5. Section 283111 "Digital, Addressable Fire-Alarm System" Fire-Alarm System" for smoke detectors in elevator lobbies to initiate emergency recall operation and heat detectors in shafts and machine rooms to disconnect power from elevator equipment before sprinkler activation and for connection to elevator controllers.

1.3 DEFINITIONS

A. Definitions in ASME A17.1/CSA B44 apply to work of this Section.

B. Service Elevator: A passenger elevator that is also used to carry freight.

1.4 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for car enclosures, hoistway entrances, and operation, control, and signal systems.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating service at each landing, coordination with building structure, relationships with other construction, and locations of equipment.
2. Include large-scale layout of car-control station.
3. Indicate maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.

C. Samples for Initial Selection: For finishes involving color selection.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and control layout and dimensions, as shown on Drawings, and electrical service including standby power generator, as shown and specified, are adequate for elevator system being provided.

D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Elevator manufacturer or an authorized representative who is trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging. Store materials, components, and equipment off of ground, under cover, and in a dry location.

1.9 COORDINATION

A. Coordinate installation of sleeves, block outs, elevator equipment with integral anchors, and other items that are embedded in concrete or masonry for elevator equipment. Furnish templates, sleeves, elevator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.

B. Coordinate locations and dimensions of other work relating to electric traction elevators including pit ladders; sumps and floor drains in pits; entrance subsills; electrical service; and electrical outlets, lights, and switches in hoistways, pits, and machine rooms.

1.10 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
2. Warranty Period: One year from date of Substantial Completion.

B. Maintenance Service:

1. Initial Maintenance Service: Beginning at Substantial Completion, provide 24 months' full maintenance service by skilled employees of the elevator Installer. Include monthly preventative maintenance, repair, or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Provide parts and supplies as used in the manufacture and installation of original equipment.

a. Include 24-hour-per-day, 7-day-per-week emergency callback service.

1) Response Time: Two hours or less.

2. Continuing Maintenance Proposal: Provide a continuing maintenance proposal from Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide one of the following:

1. Kone, Inc.
2. Thyssen Krupp Elevator Co., Basis-of-Design: Evolution 200, 5000H
3. Fujitec Co.

B. Source Limitations: Obtain elevators from single manufacturer.

1. Major elevator components, including driving machines, controllers, signal fixtures, door operators, car frames, cars, and entrances, shall be manufactured by single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with Section 407 in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

C. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and shall comply with elevator safety requirements for seismic risk Zone 2 or greater in ASME A17.1/CSA B44.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified[**and the system will be fully operational after the seismic event**]."
2. Affected peak velocity acceleration (Av) for Project's location is [**less than 0.10 (seismic risk Zones 0 and 1)**] [**greater than or equal to 0.10, but less than 0.20 (seismic risk Zone 2)**] [**greater than or equal to 0.20 (seismic risk Zones 3 and 4)**].
3. Provide earthquake equipment required by ASME A17.1/CSA B44.
4. Provide seismic switch required by ASCE/SEI 7.

5. Design earthquake spectral response acceleration short period (Sds) for Project is <**Insert value**>.
6. Project Seismic Design Category: [**A**] [**B**] [**C**] [**D**] [**E**] [**F**].
7. Elevator Component Importance Factor: 1.5.

2.3 ELEVATORS

A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturer's standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description:

1. 3 stop, front loading.
2. Machine Location: Hoistway; no machine room is provided.
3. Machine Type: Gearless traction.
4. Rated Load: 5000 lb (2270 kg).
5. Freight Loading Class for Service Elevator(s): Class A.
6. Rated Speed: 200 fpm (1.0 m/s).
7. Operation System: Selective-collective automatic operation.
8. Auxiliary Operations:

    a. Earthquake Emergency Operation: Comply with requirements in ASME A17.1/CSA B44.
    b. Automatic dispatching of loaded car.
    c. Nuisance call cancel.

9. Car Enclosures:

    a. Inside Width: 68 inches from side wall to side wall.
    b. Inside Depth: 108 inches from back wall to front wall (return panels).
    c. Inside Height: 100 inches to underside of ceiling.
    d. Front Walls (Return Panels): Satin stainless steel, No. 4 finish.
    e. Car Fixtures: Satin stainless steel, No. 4 finish.
    f. Side and Rear Wall Panels: Textured stainless steel.
    g. Reveals: Satin stainless steel, No. 4 finish.
    h. Door Faces (Interior): Textured stainless steel.
    i. Door Sills: Aluminum, mill finish.
    j. Ceiling: Satin stainless steel, No. 4 finish.
    k. Handrails**:** 1/2 by 2 inches rectangular satin stainless steel, No. 4 finish, at sides and rear of car.
    l. Floor prepared to receive resilient flooring (specified in Section 096500 "Resilient Flooring").
    m. Floor Thickness, Including Setting Materials: Coordinate thickness with material provided above plywood subfloor.

10. Hoistway Entrances:

a. Width: 54 inches (1372 mm).
b. Height: 96 inches (2438 mm).
c. Type: Two-speed side sliding.
d. Frames: Satin stainless steel, No. 4 finish.
e. Doors: Textured stainless steel.
f. Sills: Aluminum, mill finish.

11. Hall Fixtures: Satin stainless steel, No. 4 finish.
12. Additional Requirements:

a. Provide inspection certificate in each car, mounted under acrylic cover with frame made from satin stainless steel, No. 4 finish.
b. Provide hooks for protective pads and one complete set(s) of full-height protective pads.

2.4 TRACTION SYSTEMS

A. Elevator Machines: Variable-voltage, variable-frequency, ac-type gearless hoisting machines and solid-state power converters.

1. Provide nonregenerative system.
2. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.
3. Provide means for absorbing regenerated power when elevator system is operating on standby power.
4. Provide line filters or chokes to prevent electrical peaks or spikes from feeding back into building power system.
5. Provide AC motor sized for speed and capacity of the specified systems.
6. Provide unintended movement and ascending car overspeed device.

B. Suspension Means: Provide hoist cables and wedge shackles as required by the machine manufacturer.

C. Speed Governor: Provide a speed governor located at the top of the hoistway. Provide a coble and tail sheave with tension. The governor shall have an electric switch that when opened shall prevent the elevator motor from running. The governor and switch shall be capable of remote activation and reset.

D. Car Safety: A car safety device shall be attached to the underside of the elevator car sling. When active, the device shall stop the elevator level in the hoistway and within code tolerance. The device shall be equipped with a safety switch that prevents the motor from running when in the open position.

E. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work. Device installation is specified in another Section.

F. Machine Beams: Provide steel framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Section 055000 “Metal Fabrications” for materials and fabrication.

G. Guide Rails: Use only “T” shaped rails.

H. Buffers: Spring as required by code.

I. Car Frame and Platform: Bolted- or welded-steel units.

J. Guides: Provide properly sized Roller guides. Provide guides at top and bottom of car and counterweight frames. Car guides shall be a minimum of 6 inch diameter.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation systems as required to provide type of operation indicated.

B. Auxiliary Operations: In addition to primary operation system features, provide the following operational features for elevators where indicated:

1. Emergency power.
2. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors begin closing.
3. Nuisance-Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and a predetermined weight can be adjusted.
4. Loaded-Car Bypass: When car load exceeds 80 percent of rated capacity, car responds only to car calls, not to hall calls.
5. Independent Service: Rocker switch located within a Service Compartment removes car from group operation and allows it to respond only to car calls. Key cannot be removed from keyswitch when car is in independent service. When in independent service, doors close only in response to door close button.
6. Emergency Firefighter’s Service: When a smoke detector located in the machine space, control space, or elevator lobby is activated, the elevator shall automatically return to the designated or alternate floor level and park with the doors open until such time that Phase II is activated, or the fire alarm panel and firefighter’s key switch has been reset.
7. Hoistway Access: Buy use of 7 pin Best Lock cylinders located in separate fixture OR contained within the lobby pushbutton at each terminal floor landing. Access shall be possible by activation of an enable rocker switch to be located within the Service Cabinet located in the COP.
8. Automatic Operation of Lights and Fan: When elevator is stopped and unoccupied with doors closed, lighting, ventilation fan, and cab displays are de-energized after an adjustable time period of between five and 20 minutes and are re-energized before car doors open. Such system shall not have any effect on car top lighting.

2.6 DOOR REOPENING DEVICES

A. Infrared Array: Provide door reopening device with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

B. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

2.7 CAR ENCLOSURES

A. General: Provide enameled-steel car enclosures to receive removable wall panels, with car roof, access doors, power door operators, and ventilation.

1. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.

B. Materials and Finishes: Manufacturer's standards, but not less than the following:

1. Subfloor: Exterior, underlayment grade plywood, not less than 5/8-inch (15.9-mm) nominal thickness.
2. Floor Finish: Specified in Section 096519 Resilient Tile Flooring.
3. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
4. Fabricate car with recesses and cutouts for signal equipment.
5. Fabricate car door frame integrally with front wall of car.
6. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
7. Sills: Extruded aluminum, with grooved surface, 1/4 inch (6.4 mm) thick.
8. Metal Ceiling: Flush panels, with four low-voltage downlights in each panel. Align ceiling panel joints with joints between wall panels.
9. Handrails: Manufacturer's standard handrails, of shape, metal, and finish indicated.

2.8 HOISTWAY ENTRANCES

A. Hoistway Entrance Assemblies: Manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Frame size and profile shall accommodate hoistway wall construction.

B. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction based on testing at as close-to-neutral pressure as possible according to NFPA 252.

1. Fire-Protection Rating: 1-1/2 hours with 30-minute temperature rise of 450 deg F (250 deg C).

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:

1. Stainless-Steel Frames: Formed from stainless-steel sheet.
2. Star of Life Symbol: Identify emergency elevators with star of life symbol, not less than 3 inches (76 mm) high, on both inside surfaces of hoistway door frames.
3. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
4. Sight Guards: Provide sight guards on doors matching door edges.
5. Sills: Extruded aluminum, with grooved surface, 1/4 inch (6.4 mm) thick.
6. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M.

2.9 SIGNAL EQUIPMENT

A. General: Provide vandal resistant hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with LEDs.

B. Car-Control Stations: Provide manufacturer's standard recessed car-control stations. Mount in return panel adjacent to car door unless otherwise indicated.

1. Mark buttons and switches for required use or function. Use both tactile symbols and Braille.
2. Provide "No Smoking" sign matching car-control station, either integral with car-control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.

C. Emergency Communication System: Two-way voice communication system, with visible signal, which dials preprogrammed number of monitoring station and does not require handset use. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply. System shall comply with ADA requirements.

D. Car Position Indicator: Provide digital-type car position indicator, located above car door or above car-control station. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

E. Hall Push-Button Stations: Provide one hall push-button station at each landing where elevator stops.

1. Provide units with flat faceplate for mounting with body of unit recessed in wall.
2. Equip units with buttons for calling elevator and for indicating direction of travel or destination as required by system.

F. Hall Position Indicators: Provide digital-display-type position indicators, located above hoistway entrance at ground floor. Provide units with flat faceplate for mounting and with body of unit recessed in wall.

G. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1/CSA B44, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed.

H. Emergency Pictorial Signs: Fabricate from materials matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire, elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station unless otherwise indicated.

2.10 FINISH MATERIALS

A. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.

B. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.

C. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.

D. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.

E. Textured Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304 with embossed texture rolled into exposed surface.

F. Stainless-Steel Bars: ASTM A 276, Type 304.

G. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.

H. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Examine hoistways, hoistway openings, pits, and machine rooms as constructed; verify critical dimensions; and examine supporting structure and other conditions under which elevator work is to be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's written instructions.

B. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.

C. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

D. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.

E. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay final adjustment of sills and doors until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.

F. Leveling Tolerance: 1/8 inch (3 mm), up or down, regardless of load and travel direction.

G. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.

H. Locate hall signal equipment for elevators as follows unless otherwise indicated:

1. For groups of elevators, locate hall push-button stations to the side of elevator at location most convenient for approaching passengers.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

B. Advise Owner, Architect, and authorities having jurisdiction in advance of dates and times that tests are to be performed on elevators.

3.4 PROTECTION

A. Temporary Use: Temporary use of elevators is at the sole discretion of the Owner. Contractor shall submit request for use to Owner not less than four full weeks prior to proposed start of use. In the event that the Owner does not allow temporary use of elevators for construction, any costs associated with provision of temporary hoisting through to date of Substantial Completion are the Contractor's responsibility. Limit temporary use for construction purposes to one elevator for each building. Comply with the following requirements for each elevator used for construction purposes.

1. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
2. Provide strippable protective film on entrance and car doors and frames.
3. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.
4. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
5. Do not load elevators beyond their rated weight capacity.
6. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleanup, and adjustment as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
7. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).

B. Check operation of elevator with Owner's personnel present before date of Substantial Completion and again not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

3.6 MAINTENANCE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 24 months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Perform maintenance during normal working hours.

2. Perform emergency callback service during normal working hours with response time of two hours or less.

END OF SECTION 142100

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SECTION 149200 - PNEUMATIC TUBE SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide a 6” pneumatic tube system expansion to support the IU Health New Downtown Hospital.
B. The PTS for the New Downtown Hospital will be connected to the existing systems in the Pathology Building and Riley Hospital for Children via the six (6) existing tubes on the people mover structure that runs along Senate Ave. These tubes will be rerouted through the Central Utility Plant (CUP) utility tunnel and Support Service Building into the new system interchange in the hospital.
C. The scope of this specification only pertains to the tubes routed through the CUP, information about the rest of the system is provided for context only.
D. System supplier shall provide all engineering, equipment, materials, and labor for a complete turn-key six-inch (6”) automated computer-controlled expanded Pneumatic Tube System.
E. All work shall be completed in a workmanlike manner, complete in all respects including all items specified herein and as may be necessary for the satisfactory installation and operation of the specified system.
F. The contractor shall install, test, and warrant the system operation and performance.

1.2 RELATED DOCUMENTS

A. Drawings and provisions of the Contract, including General and Supplemental Conditions apply to this section.

1.3 RELATED PUBLICATIONS

A. This section relates to the local and national standards in which the pneumatic tube installation must abide by.

1. National Fire Protection Association (NFPA)
   a. NFPA 70
2. ASTM International
   a. ASTM A123/A123M
3. National Electrical Manufacturers Association (NEMA)

a. MG 1 Motors and Generators

1.4 QUALITY ASSURANCE

A. All work shall be completed in a workmanlike manner, complete in all respects including all items specified herein and as may be necessary for the satisfactory installation and operation of the specified system.
B. All equipment shall be furnished by an approved system manufacturer. Approved system manufactures include:
    a. Swisslog TransLogic Pneumatic Tube Systems
C. The equipment manufacturer shall at the time of bid, manufacture and warrant the computer-controlled pneumatic tube systems as one of their principle products.
D. The System Supplier shall regularly and presently install and warrant the computer-controlled material distribution equipment as specified herein as one of their principle products.
E. A system supplier may purchase equipment from an approved equipment manufacturer if the system supplier and manufacturer are approved by the Owner. The system supplier will be responsible for the items in this specification, including the design, layout, installation, coordination, and warranty of the equipment and associated equipment service requirements. The system supplier must have a quality assurance program in place, demonstrable to the Owner.
F. The system supplier must demonstrate a minimum of five (5) years installation experience of the approved system manufacture's equipment.
G. The System Supplier shall be fully responsible to work with the Owner, Architect, General Contractor and appointed representatives to adequately coordinate space and mechanical requirements.
H. The pneumatic tube system is a performance-based design and specification. The bid drawings show general station locations and horizontal and vertical pathways for the system. It is the responsibility of the vendor to coordinate all tube routes and equipment placement and access.
I. Equipment and parts that have been discontinued by the system manufacturer at the time of installation shall not be utilized for this project. The System Supplier shall ensure that the parts and equipment will be available for the system a minimum of ten (10) years following the system acceptance.
J. All system software and control capabilities offered must be fully developed and functioning successfully in a minimum of ten (10) other facilities at the time of bid. It is the responsibility of the System Supplier to install a previous software version if persistent software problems are realized during installation and first twelve (12) months of the system use.
K. All electrical equipment, equipment assemblies and components shall be listed with Underwriter's Laboratory (UL) and all field wiring shall be in conformance with NEC requirements. UL listing must be current at the time of bid.
L. Building Information Modeling (BIM)
    1. System design shall include BIM to design, produce, coordinate, construct and document the pneumatic tube system and components.

2. The deliverable Model shall be developed to include the system as it would be built and the processes of installing it, and to reflect final as-built conditions.
3. The coordination of BIM may be done in phases (floor by floor, area by area) at the completion of coordination, a complete set of drawings for the system shall be provided.
4. Coordinate equipment with other trades. Utilize the BIM model to perform visual, interference management, and other checks to ensure the proper coordination and access requirements for the system.
5. Design coordination meetings to coordinate the model will be required.

M. A spare part inventory allowance of fifteen-thousand dollars ($15,000) shall be provided upon the Purchaser acceptance of the system. The supplier shall recommend a spare parts list that includes the unit prices and estimated delivery times. The owner shall approve the spare parts list prior to delivery of the spare parts.

1.5 TECHNICAL SUBMISSIONS WITH PROPOSAL

A. The System Supplier shall submit product data and unit pricing for the system. Each component is considered complete including valves, control panels, motors, boards etc. The equipment required include:
1. Stations
2. Transfer Units / Diverters (1x4, and 1x6)
3. Blower Units
4. Straight tube per linear foot
5. Bends
6. Hanging material by linear foot (Including rods and clamps)
7. Low voltage communication wiring per linear foot
8. Leak-Resistant carriers

B. Provide at the time of tender with the proposal references of at least five (5) projects in the past five (5) years. Each reference shall include names and phone numbers of contacts.

C. Product Data
1. Provide the manufacturer's marked literature showing illustrations, technical data and description of equipment to be furnished.
2. Submit all physical characteristics of the proposed equipment are to be submitted. These include the critical dimensions related to length, width and height, capacity, and clearances. Suppliers are advised to respond in as much technical detail as possible. Submissions shall contain a supplier developed plan view, and elevations.

1.6 SUBMITTALS

A. System Simulation

1. System Simulations shall be provided by the system supplier and approved by the owner/owner representative prior to beginning of detailed system BIM coordination with the contractor. The system supplier and contractor are responsible for any rework associated with design efforts without owner's review/approval of the System Simulation.
2. Provide system design drawings that includes all distances utilized for the system simulation. A simulation will not be accepted without the design drawings and riser diagram updated to match the simulation inputs.
3. The system supplier shall provide a system design simulation for the estimated peak hour traffic. Ninety-five percent of transactions shall have a wait time less than 120 seconds. The simulation shall indicate the following information regarding the system performance:
   a. The average wait time for each station during the peak hour.
   b. The maximum wait time for each station during the peak hour.
   c. The number of transactions that have wait times over 30, 60, 90 and 120 seconds.
4. The system supplier shall provide a system design simulation for the estimated peak day traffic. The simulation shall indicate the following information regarding the system performance:
   a. The average wait time for each station during the peak day.
   b. The maximum wait time for each station during the peak day.
   c. The number of transactions that have wait times over 30, 60, 90 and 120 seconds.

B. Shop Drawings
1. Shop drawings are to include plan views and sections of all major components. Shop drawings shall show tube routings on architectural floor plans, tubing riser diagrams, electrical riser diagrams, right-of-way, methods of suspending and anchoring tubing and equipment, station details, equipment locations and detailed dimensions of all major components.
2. A set of coordination documents shall be provided to coordinate equipment access requirements, mechanical, electrical, structural and other details with other trades. Details should provide sufficient detail to coordinate the requirements of the system. The coordination drawings should be coordinated to provide sufficient access and space requirements for the system as installed. It is the responsibility of the System Supplier to coordinate the space and access requirements to properly maintain and access the equipment.

C. Installation schedule
1. The system upgrade shall be installed to minimize downtime of other systems. Phasing plans and schedules shall be provided by the Contractor and approved by the Owner.
2. Submit any deviation to the phasing plan and schedule in writing to the Owner for approval.

D. Test Plan
1. Equipment Testing

2. Provide a test plan that clearly defines the forms or documents that will be utilized to test the equipment as described in this document.

E. Service Agreement
1. Provide a service agreement proposal for the owner to review. The service contract must include the items outlined in section 1.10.

1.7 PERFORMANCE TESTING

A. Perform testing upon completion of the connection to the existing system.
B. Provide a test plan that demonstrates to the Purchaser or Representative of the Purchaser that the system can handle the peak load as described in the peak hour matrix.
C. The test plan shall clearly identify the process, time, and number of hospital staff to perform the peak load test.
D. The test plan shall include forms and documents required to carry out the test plan by individual stations.

1.8 PRODUCT MANUALS

A. User Manuals
1. Provide one (1) hard copy and one read-only electronic version on a CD or USB flash drive of the user operating manuals. The user operating manuals shall describe the operation of each type of station, carrier packing guidelines, and special use for the system including secure transactions. Each manual shall be in easy-to-read format including pictures and diagrams demonstrating the system use.

B. Maintenance Manuals
1. Provide one (1) bound hard copy and one read-only electronic version on a CD or USB flash drive of the complete system maintenance instructions for the system. The maintenance manuals shall include detailed information sufficient for the purchaser to execute a full maintenance program for each piece of equipment including:
   a. Exploded views of each piece of equipment and parts descriptions
   b. Wiring and electrical diagrams
   c. Mechanical and Electrical riser diagrams
   d. Starting and stopping procedures
   e. Specific maintenance and troubleshooting instructions
   f. Recommended service schedules for adjustment, lubrication and inspection.
   g. Parts list and spare parts inventory

C. Close-out Submittals
1. Provide as required by general conditions of the specification.

2. Provide record drawing for the system in its entirety. The shop drawings shall be complete including existing and new equipment and components. A partial record drawing package is not acceptable.
3. The System Supplier shall provide a record shop drawing in AutoCAD or equal for instruction and future reference by the Purchaser.
4. Provide a full system mechanical and electrical record riser diagrams.
5. Comprehensive Equipment Inventory List
6. The System Supplier shall develop an equipment inventory that includes model number, serial number and specific location (e.g. room number) for each piece of equipment.
7. Provide a list of recommended preventative maintenance for each piece of equipment.

1.9 WARRANTY

A. The System Supplier shall guarantee all components to be free from defects in material and workmanship for a period of twenty-four (24) months following the final phase of construction for the project. The System Supplier shall provide a limited warranty on the system software for a period of twenty-four (24) months.

B. System Warranty
1. Upon notice of failure of parts or workmanship of the system, the System Supplier shall promptly rectify the faulty parts or workmanship at no cost to the Purchaser.
2. Perform all system or equipment troubleshooting during the warranty period will be performed by the System Supplier. Provide sufficient manpower to fully troubleshoot the system. The Purchaser may choose to have a facility technician accompany the System Supplier; however, at no time should the Purchaser be obligated to provide man power or support in this troubleshooting process.
3. Defective parts shall be replaced with new parts of equal or greater value free of charge to the Purchaser during the warranty period. Refurbished or obsolete equipment or parts are not acceptable. The Purchaser's spare part inventory should not be utilized without express written approval from the Purchaser. All defective equipment or parts that are pulled from the Purchaser's inventory shall be replaced with new parts from the System Supplier during the warranty period at no cost to the Purchaser.
4. All labor associated with defective system troubleshooting, parts replacement and warranty related items shall be provided to the Purchaser at no cost.
5. The warranty period shall commence on the date of signed acceptance of the system. If the system is installed in phases, the warranty period shall commence at the completion of the last phase of installation.
6. The System Supplier is responsible for the system maintenance between the time of installation and the signed acceptance of the system. If the System Supplier and Purchaser agree to a phased startup, the warranty period begins at the end of the last phase of startup.

C. Software Limited Warranty

1. The System Supplier will provide the customer with a 24-hour factory Helpdesk telephone number to report problems and to troubleshoot software. This Helpdesk support shall have the ability to promptly troubleshoot the system remotely.
2. The software package at the time of Purchaser's acceptance shall be the most up to date software version with the latest update that has been tried and tested for a period of no less than 3 months.
3. If the software fails to perform according to specifications, the vendor will provide support to help the customer bring the software to operational mode, either through an emergency software fix or through some bypass procedures.
4. If the latest software version and update fail to meet the level of service required due to excessive system downtime or malfunction of equipment as a result of the software, the Purchaser may request the vendor to install an earlier software version or update at the System Supplier's cost.

1.10 SERVICE AGREEMENT PROPOSAL

A. In addition to the normal warranty service, a service agreement shall be provided for the preventative maintenance on the equipment. The service agreement shall extend for a period of twenty-four (24) months.

B. During the warranty period, the System Supplier is responsible for the proper maintenance of the system.

C. The schedule of all service and maintenance agreements on the system shall be coordinated with the purchaser.

D. After the first ninety (90) days, the System Supplier shall perform as-needed repair services within twenty-four (24) hours after notification by the Purchaser(s), Monday through Friday between the hours of 8:00 A.M. through 5:00 P.M., excluding Holidays, at no additional cost to the Purchaser. If such services commence prior to 8:00 A.M., Monday through Friday, or extend beyond 5:00 P.M., no additional service charges can be applied to the Purchaser.

E. Service Agreement includes:
   1. System Supplier shall provide, whenever available or required, software support, which includes, applicable hardware/software corrections/fixes/updates, and remote configuration (reprograms).
   2. Quarterly inspection, cleaning and maintenance of all equipment.
   3. Both expendable and non-expendable parts shall be replaced without additional cost to Purchaser.
   4. The System Supplier shall maintain a service maintenance log for the system. The maintenance log shall remain on-site. Maintenance log is to be signed by System Supplier's Technician and reviewed with the Purchaser quarterly.
      a. Include a record of maintenance in accordance with the System Supplier's recommendations and provide other information as required by the facility to meet all licensing, accrediting and regulatory agency requirements.
      b. Clearly identify the equipment serviced by model number and serial number.
      c. Include an itemization and description of services performed, including electrical checks and calibration reading.

d. List any parts replaced.
e. Include the service date(s) and time(s).
f. Give the name of the Service Technician who performed the service.

F. Service Agreement Personnel
1. System Supplier's Service Technicians are responsible to lead and coordinate the requirements of the service agreement. System Supplier's Service Technician shall be available Monday through Friday, 8:00 A.M. to 5:00 P.M., excluding holidays, to act as a central point of contact with Purchaser's personnel.
2. System Supplier's Representative shall institute and maintain appropriate supervision of all persons providing services. System Supplier shall work independently on designated assignments in accordance to the service agreement.
3. System Supplier service personnel shall be appropriately licensed, certified, credentialed, or trained to perform the preventive maintenance services.
4. System Supplier shall assume the sole responsibility for the timely completion of all activities assigned or to be performed hereunder.
5. System Supplier shall assign a sufficient number of employees to perform the required work.
6. Identification Badges and Dress Code
a. System Supplier's staff shall be appropriately identified as required by the Purchaser.

1.11 WORK INCLUDED

A. The contractor shall furnish and install all motor starters and drives with properly sized thermal overload protection in each at the blower packages.
B. All new equipment will be connected by Ethernet to the system control center utilizing the hospitals network. The vendor is required to coordinate the requirements of the hospital network and the network drops.
C. The system electronics shall not interfere with telemetry equipment.
D. Coordinate the temperature and humidity requirements at the computer control area.

1.12 WORK PROVIDED BY OTHERS

A. Architectural enclosures of the equipment and new stations.
B. Final painting of tubing or other unfinished equipment, if or when required.
C. Removal and replacement of ceilings, if or when required.
D. Furnishing and setting of sleeves and sleeve openings through walls and floors.
E. Cutting, core boring, patching or painting of walls, floor or ceilings required by the installation.
F. Patching/fireproofing of sleeves and openings in floors, walls and ceilings where required.
G. Furnish and install all access panels as required.
H. Furnish and install emergency electrical power as follows:

1. 208/230/460-volt, 50/60 hertz, 3-phase power source and fused disconnect to support a 10 HP motor within five feet of the blower package.
2. 120-volt, 50/60 hertz, 1-phase power source for each station, diverter and blower package.
3. 120-volt, 50/60 hertz, 1-phase power source at the computer control area. This power source shall be uninterrupted and dedicated.

I. Data Connection
1. An active Ethernet network jack with available high-speed internet access installed within six (6) feet of the System Control Center.
2. An Active Ethernet network jack connected to the hospital network installed within six (6) feet of each new blower, station, and transfer unit/diverter.

J. Excavation, backfill, concrete/asphalt sawing, landscaping, repaving and finished surface for underground tube or cable installation, if or when required.

K. Provide elevator/hoist service, if required.

L. Clean off plaster, mortar and other debris on/in pneumatic tube equipment resulting from activities of other trades.

M. Repair or replace any damage to pneumatic tube equipment resulting from activities of other trades.

N. Temporary power to facilitate testing when required.

O. Fire protection and asbestos abatement.
1. Identification of all areas with unabated asbestos.
2. All inspections, testing, monitoring, abatement and containment for any hazardous material including asbestos, which is encountered anytime in the duration of the project.

P. Provide the necessary licenses and permits.

PART 2 - PRODUCTS

2.1 SYSTEM DESIGN REQUIREMENTS

A. The System shall be a six-inch (6") computer-controlled pneumatic tube system consisting of tubing, stations, transfer units, blower packages, computer control center and carriers.
1. All new system components shall be installed on Emergency Power but installed as a non-critical system.
2. The system shall transport carriers at an average velocity of twenty (20) feet per second.
3. Stations shall be capable of dispatching carriers that weigh seven (7) pounds (payload and carrier).
4. The system shall be designed to have a group of stations (Zone) connected through transfer units (Diverters) to a minimum of one (1) blower and shall function independently.

5. The number of stations per zone shall be evaluated through the system design and simulation and must meet the requirements. Each zone shall have a maximum of ten (10) stations per zone.
6. The system zones shall be interconnected through inter-zone connections and by means of transfer units (Diverters). The system shall provide multiple inter-zone storage/ transfers between each of the zones.
7. The system shall be installed with carrier tracking features including inline sensors and control software.
8. The system shall include a card reader system for access to the equipment. The card reader for the system shall function with the hospitals badges and shall connect to the hospitals active directory.
9. The modular design of the System components shall permit changes in the number of stations and/or zones as Owner requirements change.
10. A 115 VAC duplex receptacle and device on/off switch shall be provided at each station, transfer unit, exchanger and blower package.
11. Each station shall include diagnostic capability at the unit.

2.2 SYSTEM OPERATION

A. System Control Center operation should include capacity of not less than nine hundred and ninety-six (996) stations without the need for modifications to the central control and existing station control.
B. The system software shall verify that all components of the system are operating properly before the carrier is dispatched through a closed loop control.
C. The system shall be computer-controlled with a graphic display of system information and diagnostic operation of system components.
D. The dispatching, routing, and storage of carriers shall be automated through the system control center to provide automatic unattended transmission of carriers between any two (2) stations.
E. The system control center shall make the selection of the shortest, most direct routing of all carriers to their destinations. Carriers that are being transported within a zone shall have the ability to turn around at the nearest common transfer unit.
F. The control center shall be programmable to provide individual priorities for each of the stations in the system on a send and receive function. These priorities are to be easily adjustable by the Owner. The system shall dynamically alter transaction priorities based upon transaction wait times.
G. Individual stations or zones shall be able to be shut down without affecting the remainder of System.
H. Systems with more than one zone shall allow multiple carriers to be in transit simultaneously. The system shall allow all station dispatchers to be loaded simultaneously, destinations to be selected and all transactions processed automatically until the system is clear.
I. Provide automatic empty carrier redistribution:
    1. The users shall have the ability to return excess carriers into the system by pushing an empty carrier redistribution button on the control panel. The system will dispatch excess empty carriers to carrier-deficient stations, which shall be automatically identified and selected by the System.

2. The redistribution priorities include:
   a. Any stations that have zero (0) carriers present.
   b. Station having the greatest difference between carriers assigned and carriers present
   c. Should the deficiency ratio be exactly the same for several stations in the system, then the computer will route the empty carriers to stations that are nearest the sending station.

J. A transaction to a station that becomes unavailable after dispatch shall be rerouted to the origin station. A notification at the origin station shall inform the users of the returned carrier.

K. Carriers in process or pending when the system is shut off shall deliver to their destination station. Any new requests to send shall be rejected.

L. Carriers in process when a power failure occurs shall be delivered to their destination after the power is restored. The control center shall be equipped with UPS to retain record of carriers in transit.

2.3 SYSTEM INTERCHANGE

A. Provide interzone connections between each of the zones for temporary storage and transfer of carriers between zones.

B. Provide simultaneous carrier storage and independent zone operation.

C. The system interchange shall be designed to provide multiple interzone connections to the system for each zone.

D. The system control center shall make the selection of the shortest, most direct routing of all carriers to their destinations. Carriers that travel through multiple zones shall be minimized through the system simulation.

E. Systems that use shuttle zones or connection zones shall minimize the number of carriers that pass through multiple zones during transport.

F. If a high capacity transfer system is utilized as the primary interchange between the zones, provide a duplicate redundant high capacity transfer system is required with connections between each of the zones.

2.4 EQUIPMENT

A. Transmission Tubing
   1. Transmission tubing shall be cold-rolled, electric-welded, flash-removed, degreased, flash and hot dip galvanized sixteen (16) gauge steel with a nominal six-inch (6") outside diameter. One end shall be belled and the other end chamfered to provide optimum joints.
   2. Bends shall be the same material as transmission tubing with belled and chamfered ends. They shall be formed to a nominal centerline radius of not less than forty-eight inches (48") and shall maintain a uniform cross section throughout the length. The cross section shall be free from wrinkles and distortions. No expanded bends or field modified bends shall be allowed in the system.

3. All pipe utilized for the project shall be new. Straight pipe and bends cut in the field shall be cut square, deburred, and ends mandreled round.
4. Solid steel slip sleeves or split steel gasketed bolted sleeves shall be used for a field cut joint and at all equipment connections. Split sleeves shall be used at all connections of serviceable equipment. All sleeves shall be of the same gage as the tubing.
5. All joints shall be sealed with a suitable airtight compound and wrapped with a plastic tape. All joints shall be airtight.
6. Support hangers for tubing shall be 3/8" pre-threaded rod, galvanized and threaded into the building structure. Unistrut with tube clamps or tear-drop hangers fastened to the rod shall support the tubing. The tube shall be supported as follows:
   a. Minimum every ten (10) feet of straight tubing
   b. At every floor of vertical runs
   c. At each end of each bend
   d. At equipment connections
7. Provide sway bracing for both tangential and perpendicular forces to reduce tube movement from carrier passage through the system. Sway bracing shall be installed within 10'-0" of all stations, at each bend and at intervals not to exceed 40'-0". Additional sway bracing will be required if tube movement exceeds one half inch (1/2") from center with a fifteen (15) pound force applied to the center of the tube.
8. Pipe that is installed through a building expansion or seismic joint shall be installed to support the movement of the building expansion and contraction or seismic motion without damaging adjacent tubing. A pipe through the building expansion joint shall be installed with bolted couplings on either side of the joint such that the pipe and bolted couplings can be readily replaced.
9. The tube routing and equipment placement shall not be installed over patient care areas or hospital sound sensitive areas including; conference rooms and physician sleep rooms. In areas where installation over these areas is unavoidable, the system supplier shall install sound insulation on the tubes and architectural sound attenuation boxes around the equipment that are over patient areas. The sound insulation should extend a minimum of six feet (6'-0") on either side of the affected area. The Contractor is to submit all sound attenuation measures and insulation cut sheets to the Owner for approval. Insulation shall be a minimum of one and one-half inch (1-1/2") thick layer of one and one-half (1-1/2") pcf density fiberglass insulation with a dust cover and taped joints over the tubing or equivalent.
10. All pipe or bends installed on a roof and exposed to the elements shall have all joints brazed and covered with heat shrink sleeves. The tubing shall be pressure tested to ensure no moisture can enter through the joints. The PTS supplier shall submit heat shrink sleeve and pressure testing details to the Owner for approval before proceeding with the installation.

B. Transfer Units (Diverters)
   1. Provide Transfer units (Diverters) as the means to route carriers through the system.

2. Transfer units shall be installed with split sleeves and sway braced against motion.
3. Transfer units shall be located to allow for complete and clear access to service mechanical and electrical components. The transfer units shall be constructed of galvanized steel with side accessible panels.
4. Transfer units are to be suspended from the ceiling using 3/8" galvanized threaded rods or supported from the floor with a uni-strut structure. Transfer units shall be sway braced in both tangential and perpendicular directions.
5. The offset through the transfer unit shall be gradual using a curved tube section. The transfer unit types shall be as follows:
   a. One Line In; Four Lines Out
   b. One Line In; Six Lines Out
6. The transfer units shall properly align with the transmission piping with minimal variance. Carriers that pass through the transfer units shall not hit the transfer unit or opposing transmission lines.
7. All transfer units shall have non-contact carrier position sensors.
8. Transfer units are to be controlled through a replaceable circuit board that is installed within the transfer unit.

C. Stations
1. Stations shall consist of a self-supporting enclosure which houses the dispatch equipment, receive equipment and electrical controls enclosed in a sheet metal housing. The dispatch equipment, receive equipment and electrical controls are to be interchangeable.
2. All mechanical and electrical components shall be front accessible and removable for repair or replacement. If keys are required to access the front of the station, provide a key for each station identified in the specification.
3. The station enclosure should be sufficiently designed to minimize movement during carrier dispatch and receipt.
4. Station shall be wall recessed, up-send, down-receive style, and provide an air cushion for soft delivery of the carriers.
5. The pressure relief valve shall be located on the bend or straight pipe directly above the station.
   a. Ideally the pressure relief valve is to be located between six (6) and ten (10) linear feet from the station nipple.
   b. In no case shall the pressure relief valve be located less than six (6) linear feet or more than fifteen (15) linear feet from the slide plate.
6. The carrier receiving area shall be designed to reduce carrier arrival noise. The station padding in the station shall be replaceable.
7. All visible metal surfaces of the station shall be factory painted. A trim frame shall be used for final mating to the wall. Bright metal finish parts shall be stainless steel, brushed aluminum or chrome plated.
8. The system shall utilize non-contact sensors at the station to detect the position of the carriers at the station.
9. The dispatcher shall hold one carrier at a time.
10. The receiver shall be independent of the dispatcher.

11. The dispatcher shall enable a carrier to be staged for dispatch while a carrier is incoming to a station.
12. If the carriers are received in a bin, the receiving bin shall be integral with the station and shall have the ability to receive no less than four (4) carriers.
13. When station's receiver becomes full, that station's receive and dispatch functions shall be disabled. Carriers will not be dispatched to a station that is overloaded. A message on the station display and at the system control center shall indicate the full condition. The condition shall automatically reset upon carrier removal from receiver.
14. Each station shall have storage within the station housing for a minimum of three (3) carriers. Stations that do not have the storage as an integral part of the station will require an empty carrier storage bin. The empty carrier storage bin shall be recessed and located adjacent to the high capacity station.
15. Destinations that are unavailable shall be rejected at the origination station. Unavailable destinations include stations that are:
    a. Incorrectly entered (non-existing) stations
    b. Out-of service stations
    c. Receiving station bin exceeds capacity
16. Each station shall have an audible alarm to announce the carrier arrival.
17. The system computer controls shall allow for "STAT" transactions. A code shall be used by the system operators to identify a transaction as being a "STAT" transport. The "STAT" transport shall take priority over all other system transactions.
18. The system shall have the capability of sending secure items through the system using card swipe to control access to these items at the receiving station.
19. The system shall have the capability to track the last ten transactions sent from a station on that station's control panel.
20. Provide new stations with touch screen control panels as follows:
    a. A keypad for destination and special function selection.
    b. A minimum of twelve (12) programmable function keys shall be integrated into the station keypad for one-touch station address, specialized system requirements, diagnostics, remote indicators and various maintenance and data retrieval options.
    c. The station dispatch panel shall have the capability to track the last ten transactions sent from a station on that station's control panel.
    d. All station controls shall be solid state plug-in units for fast replacement.
    e. Provide the ability to manually diagnose station mechanics from the station control panel.
    f. Provide the ability to clear station alarms from the station keypad.
    g. The control panel shall be a touchscreen display. The display panel shall display a message indicating:
        1) Station is signed on/off
        2) Send denied insert carrier, retry
        3) Send cancelled by this user
        4) Incoming carrier count, carrier origin, and transaction type
        5) Invalid station number
        6) Selection not in service or signed off

7) Carrier returned due to failure
8) Destination receiving bin full
9) The station receiving bin is full
10) Return empty carriers
11) Zone down
12) Carrier forwarded
13) Releasing secure carrier
14) Secure carrier arrival
15) Date and time, synchronized with the central computer
16) Destination address name
17) Help menu selections
18) User instructions
19) A directory of stations
20) Special functions
21) Emergency Shutdown

21. Other operator feedback information
    a. A ”Send" or "Send/Enter” key to activate the dispatch after destination selection or to enter data for special functions.
    b. A “Cancel/Clear” key to allow for transaction cancellation or clearing of the display during special function activation.
    c. A “Send Empty” key for surplus carrier redistribution.
    d. A ”Menu” key for selecting special functions.
22. Provide 122 new stations with capacity to support 33 future stations as listed below.

New/Existing/Demo	Building	Level	Area Name
New	New Downtown Hospital	PL	Rapid Response Lab
New	New Downtown Hospital	PL	Rapid Response Lab
New	New Downtown Hospital	PL	Oncology Lab
New	New Downtown Hospital	PL	Blood Bank
New	New Downtown Hospital	PL	Blood Bank
New	New Downtown Hospital	PL	Wound Center
New	New Downtown Hospital	PL	Rad./Onc.
New	New Downtown Hospital	PL	Pharmacy
New	New Downtown Hospital	PL	Pharmacy
New	New Downtown Hospital	PL	Pharmacy
New	New Downtown Hospital	PL	Pharmacy
Future	New Downtown Hospital	PL	Clinic
New	New Downtown Hospital	L1	Retail Pharmacy
New	New Downtown Hospital	L1	ED Sat. Pharm.
New	New Downtown Hospital	L1	ED 1
New	New Downtown Hospital	L1	ED 2 (Trauma)
New	New Downtown Hospital	L1	ED 3
New	New Downtown Hospital	L1	ED 4

New/Existing/Demo	Building	Level	Area Name
New	New Downtown Hospital	L1	ED 5
New	New Downtown Hospital	L1	ED 6
Future	New Downtown Hospital	L1	ED 7
Future	New Downtown Hospital	L1	ED 8
New	New Downtown Hospital	L2	Imaging
New	New Downtown Hospital	L2	Imaging
New	New Downtown Hospital	L2	Imaging
New	New Downtown Hospital	L2	Imaging
New	New Downtown Hospital	L2	Imaging
New	New Downtown Hospital	L2	Cardio Diagnostics
New	New Downtown Hospital	L2	Cardiology
Future	New Downtown Hospital	L2	Clinic
Future	New Downtown Hospital	L2	Clinic
Future	New Downtown Hospital	L2	Clinic
New	New Downtown Hospital	L3	Phlebotomy
New	New Downtown Hospital	L3	Apheresis
New	New Downtown Hospital	L3	CRC
New	New Downtown Hospital	L3	Cell Therapy
New	New Downtown Hospital	L3	IP Dialysis
New	New Downtown Hospital	L3	Infusion
New	New Downtown Hospital	L3	Infusion
New	New Downtown Hospital	L3	Infusion
New	New Downtown Hospital	L3	OP - BMT
New	New Downtown Hospital	L3	Infusion Pharmacy
New	New Downtown Hospital	L3	Med Onc
New	New Downtown Hospital	L3	Med Onc
Future	New Downtown Hospital	L3	Clinic
Future	New Downtown Hospital	L3	Clinic
Future	New Downtown Hospital	L3	Clinic
New	New Downtown Hospital	L4	Motility
New	New Downtown Hospital	L4	Pre/Post
New	New Downtown Hospital	L4	Pre/Post
New	New Downtown Hospital	L4	PACU
New	New Downtown Hospital	L4	Pre/Post
New	New Downtown Hospital	L4	PACU
New	New Downtown Hospital	L4	PACU
New	New Downtown Hospital	L4	Cath/EP
New	New Downtown Hospital	L4	IR/NIR

New/Existing/Demo	Building	Level	Area Name
New	New Downtown Hospital	L4	GI / Endo
New	New Downtown Hospital	L4	OR Core - Amb Surgery
Future	New Downtown Hospital	L4	OR Core
Future	New Downtown Hospital	L4	Pre/Post
Future	New Downtown Hospital	L4	Pre/Post
New	New Downtown Hospital	L5	PACU
New	New Downtown Hospital	L5	PACU
New	New Downtown Hospital	L5	Pre/Post
New	New Downtown Hospital	L5	Pre/Post
New	New Downtown Hospital	L5	Pre/Post
New	New Downtown Hospital	L5	Extended Recovery/Obs.
New	New Downtown Hospital	L5	Cyto. / F.S.
New	New Downtown Hospital	L5	OR Control
New	New Downtown Hospital	L5	OR Sat. Pharm.
New	New Downtown Hospital	L5	OR Core
New	New Downtown Hospital	L5	OR Core
New	New Downtown Hospital	L5	OR Core
New	New Downtown Hospital	L5	OR Core
Future	New Downtown Hospital	L5	OR Core
Future	New Downtown Hospital	L5	Pre/Post
Future	New Downtown Hospital	L5	Pre/Post
New	New Downtown Hospital	L6	Lab - Point of Care Testing
New	New Downtown Hospital	L6	Sterile Processing
New	New Downtown Hospital	L6	Facilities Control Room
New	New Downtown Hospital	L8	Acute
New	New Downtown Hospital	L8	Acute
New	New Downtown Hospital	L8	PCU
New	New Downtown Hospital	L8	PCU
New	New Downtown Hospital	L8	ICU
New	New Downtown Hospital	L8	ICU
Future	New Downtown Hospital	L8	IPU
Future	New Downtown Hospital	L8	IPU
New	New Downtown Hospital	L9	Acute
New	New Downtown Hospital	L9	Acute
New	New Downtown Hospital	L9	PCU
New	New Downtown Hospital	L9	PCU

New/Existing/Demo	Building	Level	Area Name
New	New Downtown Hospital	L9	ICU
New	New Downtown Hospital	L9	ICU
Future	New Downtown Hospital	L9	IPU
Future	New Downtown Hospital	L9	IPU
New	New Downtown Hospital	L10	Acute
New	New Downtown Hospital	L10	Acute
New	New Downtown Hospital	L10	PCU
New	New Downtown Hospital	L10	PCU
New	New Downtown Hospital	L10	ICU
New	New Downtown Hospital	L10	ICU
Future	New Downtown Hospital	L10	IPU
Future	New Downtown Hospital	L10	IPU
New	New Downtown Hospital	L11	Acute
New	New Downtown Hospital	L11	Acute
New	New Downtown Hospital	L11	PCU
New	New Downtown Hospital	L11	PCU
New	New Downtown Hospital	L11	ICU
New	New Downtown Hospital	L11	ICU
Future	New Downtown Hospital	L11	IPU
Future	New Downtown Hospital	L11	IPU
New	New Downtown Hospital	L12	Acute
New	New Downtown Hospital	L12	Acute
New	New Downtown Hospital	L12	PCU
New	New Downtown Hospital	L12	PCU
New	New Downtown Hospital	L12	ICU
New	New Downtown Hospital	L12	ICU
Future	New Downtown Hospital	L12	IPU
Future	New Downtown Hospital	L12	IPU
New	New Downtown Hospital	L13	Acute
New	New Downtown Hospital	L13	Acute
New	New Downtown Hospital	L13	PCU
New	New Downtown Hospital	L13	PCU
New	New Downtown Hospital	L13	ICU
New	New Downtown Hospital	L13	ICU
Future	New Downtown Hospital	L13	IPU
Future	New Downtown Hospital	L13	IPU
New	New Downtown Hospital	L14	Acute
New	New Downtown Hospital	L14	Acute

New/Existing/Demo	Building	Level	Area Name
New	New Downtown Hospital	L14	PCU
New	New Downtown Hospital	L14	PCU
New	New Downtown Hospital	L14	ICU
New	New Downtown Hospital	L14	ICU
Future	New Downtown Hospital	L14	IPU
Future	New Downtown Hospital	L14	IPU
New	New Downtown Hospital	L15	Acute
New	New Downtown Hospital	L15	Acute
New	New Downtown Hospital	L15	PCU
New	New Downtown Hospital	L15	PCU
New	New Downtown Hospital	L15	ICU
New	New Downtown Hospital	L15	ICU
Future	New Downtown Hospital	L15	IPU
Future	New Downtown Hospital	L15	IPU
New	New Downtown Hospital	L16	Acute
New	New Downtown Hospital	L16	Acute
New	New Downtown Hospital	L16	PCU
New	New Downtown Hospital	L16	PCU
New	New Downtown Hospital	L16	ICU
New	New Downtown Hospital	L16	ICU
Future	New Downtown Hospital	L16	IPU
Future	New Downtown Hospital	L16	IPU
New	Support Service Building	PL	Central Distribution
New	Support Service Building	PL	Morgue
New	Support Service Building	PL	Pharmacy Inventory Control
Existing	A-East	L3	Med/Surg
Existing	A-East	L3	Med/Surg
Existing	A-East	L4	Med/Surg
Existing	A-East	L4	Med/Surg
Existing	A-East	L5	Med/Surg
Existing	A-East	L5	Med/Surg
Existing	A-East	L6	Med/Surg
Existing	A-East	L6	Med/Surg
Existing	A-East	L7	Med/Surg
Existing	A-East	L7	Med/Surg
Existing	A-East	L8	Med/Surg
Existing	A-East	L8	Med/Surg

New/Existing/Demo	Building	Level	Area Name
Existing	A-East	L8	Satellite Pharmacy
Existing	Neuroscience	LL1	LL MRI Nurse stationLL134 Ph# 963-7115
Existing	Neuroscience	L1	1st FL Pharmacy RM 1074Ph963-7100
Existing	Neuroscience	L2	2nd FL MedRecords Rm 2216 by Psychiatry 963-7260
Existing	Neuroscience	L3	3rd FL Blood draw RM 3155 by ENT ph#963-7466
Existing	Neuroscience	L5	Infusion Medication 5th Floor Room5054g
Existing	Neuroscience	L5	CRC Equipment Rm 5116 NE corner

D. Blowers
1. Blower units shall be modular, factory assembled, complete with integral vibration isolators, screen cleanout boxes and air shifting valves as required.
2. Blowers shall be located to allow complete and clear access to service mechanical and electrical components.
3. Blowers shall be of the regenerative type.
4. Blowers may use a variable frequency drive (VFD) for controlling the velocity of the carriers in the system if provided by the vendor as a standard product. During all performance testing of the system the speed should be set to the standard operating velocity.
5. Furnish and install motor starters with properly sized thermal overload protection in each phase at the blower locations.
6. The blower package shall automatically turn off during periods of non-usage to conserve energy.
7. Provide sensors to verify the blower is running for both pressure and vacuum.
8. Zone blower packages shall be designed to be mounted on floor.
9. All visible metal surfaces shall be finished with a factory paint.
10. Air piping will be 4” diameter up to 100’ long. If longer than 100’, air piping shall be of the same tube specified for carrier lines complete with all necessary tees and elbows.
11. Zone blower packages are to be located in mechanical rooms. If the blower unit is installed in areas that exceed the noise requirements of the building or are required to be less than 65 dB(A) shall be sound deadened with sound insulation and intake and exhaust mufflers.

E. Control Center

1. Provide a new server-based control center. The server must be independent from other hospital servers. The server must be connected to the server for the existing pneumatic tube system but able to operate independently if connection is interrupted. The server shall have a backup server to help operate the system in the event that the primary server fails.
2. The server shall be installed on emergency power and include an uninterruptible power supply (UPS) for the new control center.
3. The manufacturer shall provide a computer capable of running the required software, as well as a word processor application, a spreadsheet application and a web browser application.
4. The control center software shall be capable of executing multiple concurrent transactions, while allowing for system monitoring, error handling and real-time transaction data retrieval.
5. The control center shall control all electro-mechanical equipment and manage system-wide network communications.
6. The control center shall accept station generated user commands and execute transactions accordingly.
7. The control center software shall employ an algorithm that dynamically builds transaction routes based on the resources available at that point in time, and then selects the most efficient route to complete a given delivery.
8. The control center shall be programmable to provide individual priorities for each of the stations in the system on a send and receive function. These priorities are to be easily adjustable by the Owner. The system shall dynamically alter transaction priorities based upon transaction wait times.
9. The control center shall include a graphical user interface that allows for transaction monitoring, settings and option configuration, error handling, transaction data retrieval and manual operation of all equipment.
10. The database shall be a database capable of real-time documentation of every transaction request, including:
    a. Transaction status data
    b. Transaction time stamp data
    c. Transaction carrier identity
    d. Transaction content identity
    e. Transaction user identity
11. The control center shall include a standalone web application with a graphical user interface to enable the monitoring of transactions and the review and analysis of historical transaction data.
12. The control center shall support both serial and Ethernet communications to the stations, diverters and blowers.
13. The transaction data generated by the control center shall reside in the database and be fully accessible to the hospital.
14. The control center shall support remote access protocols to so that technicians located outside the hospital can access the system’s engineering controls.
15. The control center shall support traditional interzone systems, as well as blower group systems.

16. The control center shall support empty carrier management, including storing empty carriers within specially designated tubing and automatically managing the acceptance and distribution of empty carriers to and from stations.
17. The control center shall have the ability to produce and send to all station displays user developed discrete messages.
18. The control center shall provide for on/off periods per day per station.
19. The control center shall process carriers by an incoming/outgoing priority scheme. Owner will work with vendor with relative priorities for each station during system start up.
20. The control center shall provide password protection for all levels of system control.
21. The control center shall provide a menu command to purge either the entire system or an individual zone
22. The control center shall provide an emergency stop feature.
23. The control center shall provide the following display windows for operator interaction:
    a. System Navigator – Displays the system as a directory tree. System commands and parameters are accessed through this window.
    b. Traffic – Allows for the viewing of all active transactions.
    c. Current Alarms – Allows maintenance operators to view problems within the system and provides details on the active alarms. Diagnostic screens allow for corrective action.
    d. Advisor History – Displays a list of advisories.
    e. Alarm History – Displays a list of alarms.
    f. Carrier Counts – Displays the number of carriers at each station, the number of incoming carriers, and the date the count was last updated.
    g. Journal – Allows maintenance operators to create messages in the system's notepad.
    h. Maintenance History – Displays cycles of each system device since its last preventive maintenance.
    i. Purge History – Displays results of purges of the entire system or by zone.
    j. Station Summary – Displays all information pertaining to stations including address, priorities, type, zone, COM line and name.
    k. User History – Lists who logged in or out of the system.
    l. Transaction History – Displays transaction numbers, sending and receiving station involved and time for each transaction.
24. By manipulating keyboard of graphic display it shall be possible to utilize the maintenance program.
25. Provide preventative and breakdown maintenance program.
    a. Access in zone that has zone control switch in "off" position. Other zones shall continue to operate normally when maintenance program is being used for one or more zones.
    b. Through keyboard manipulation, set or reset electromechanical or pneumatic component under computer control of a turned off zone including the stations. Manually cycle all component of the zone at required intervals and analyze operation.
26. The computer printer shall have the following capabilities:

a. Provide hard copy record of individual alarms and transactions.
b. In the event of an alarm, visually display or print out nature of alarm, probable cause, and location of malfunction. Store number and type of alarm in computer memory to be available upon request.
c. Print time and date each alarm is cleared.
d. Print displays on command from keyboard.
e. Print time of power loss and power restoration for control center power failures.

F. Smoke / Fire Detection
1. Fire safety equipment shall be installed by others according to NFPA 101 and NFPA 72.
2. The pneumatic tube system provider shall provide a set of isolated electrical contacts for each blower that is connected to the system control center.
3. The pneumatic tube system provider shall coordinate with the general contractor on the connection of the fire safety system to the pneumatic tube system. The systems will be connected such that if smoke is detected in the main interchange near the blowers/air intake, the entire pneumatic tube system shall be placed into alarm and a notification at the control center shall indicate the reason the system is in alarm.

G. Carriers
1. Provide Five Hundred (500) clear leak-resistant carriers that are sealed by a gasket that upon closure forms a leak-resistant barrier for liquid and vapor.
a. Clear inside dimensions: 4-1/2” diameter by 15-5/8” length.
b. Carriers shall be bi-directional clear molded plastic and side opening for full-access.
c. Carrier latches shall be easy open positive closure latches.
d. The carrier wear bands are to be of the replaceable type.
e. Carriers shall be capable of carrying: specimens, medications, x-ray film, 1,000 ml IV bags with up to 100 ml's additives.
2. Provide Five Hundred (500) carrier liners for cushioning small items. The type of liners (thin or full) is to be coordinated with the Purchaser sixty (60) days prior to completion of the project.

H. Testing Devices
1. Provide system diagnostic capabilities at each piece of equipment. The diagnostic capabilities shall enable the Owner's staff to fully trouble-shoot and evaluate the equipment including the system communication interface, control boards and connections, wiring and mechanical response.
2. Provide the Owner with any special maintenance or diagnostic tools required for the system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. It is the responsibility of the Contractor to field verify all dimensions. Report in writing to the Owner or Owner's representative any discrepancy or conditions that will prevent the correct installation of the system before performing the work.
B. All field measurements are to be properly coordinated with the fabrication schedule and construction process to avoid a delay in the work.

3.2 EQUIPMENT DELIVERY AND STORAGE

A. The Contractor shall coordinate the delivery schedule of the equipment with the Owner. The Contractor is responsible to receive, unload, and store all equipment associated with this section. The delivery of equipment should be scheduled to provide proper work flow to meet the project needs.
B. All equipment shipped, moved and stored shall be properly protected. All equipment damaged during shipping, handling and storage shall be replaced with new.
C. The System Supplier is responsible for the safe storage of equipment on-site. All equipment stored on-site shall be stored on platforms, pallets or other supports. The System Supplier is to coordinate with the Purchaser an on-site storage location for the equipment. The System Supplier is responsible for damaged equipment in this section due to improper storage of the equipment.
D. Enclosures and housings for equipment installed during the initial phases of construction shall be properly protected to avoid damage through the project. Stations shall have a protective covering to avoid collection of waste and debris. Protective coverings can be removed during the equipment fit out with mechanical and electrical components. The access panels on the transfer units are to remain in place unless specifically working on the equipment.

3.3 INSTALLATION

A. Provide the services of a service technician who is experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installation, adjustment, and testing of the equipment.
B. The Contractor's installation team shall maintain orderly and clean working areas. The installation teams shall keep the working areas free from waste and debris. Equipment shall be neatly organized and safely stored each day. At the completion of the final phase of the project, all tools, construction equipment and machinery shall be removed.
C. If the System Supplier fails to remove waste, equipment, or debris at the completion of the work, the Purchaser may do so at the cost of the System Supplier.
D. The Purchaser can request a different installation team if the current installation team is not adequately installing the system in the specified manner or if the team fails to meet the standards identified by the Purchaser.

E. The System and components shall be assembled and installed in accordance with contract documents, applicable codes and regulations, and approved shop drawings.
F. Install all system components in compliance with the system manufacturers latest installation instructions.
G. The System Supplier shall properly coordinate installation with other trades including the mechanical and electrical trades so as to ensure the system will be a complete and properly functioning system.
H. The System Supplier shall submit detail drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Templates and installation requirements required to coordinate with other trades shall be provided.
I. The System Supplier shall coordinate the correct location and installation of all floor sleeves, concrete inserts, concrete pads, anchor bolts and other anchors that are imbedded in the concrete.
J. The System and components shall be anchored and fastened to building construction as required for a stable, secure installation. All exposed parts of the System and finish components shall be closely fit and joined to provide a neat uniform appearance.
K. The System Supplier shall coordinate the project schedule with the Purchaser. The phasing plan and schedule shall be reviewed with the Purchaser thirty (30) days prior to any equipment or system disruptions.
L. All existing equipment or system disruptions shall be coordinated with the Purchaser and requires a minimum of two (2) weeks advance notice upon the Purchasers approval.
M. The system components shall be cleaned and returned to a new unblemished state. Equipment with scratches, dings, dents are not acceptable. Equipment that is damaged during installation shall be either replaced with new or field refinished such that there is no evidence of field refinishing work.
N. Coordinate the use of the hospital elevators for equipment and personnel during construction.
O. Comply with all dust control and infection control measures required by the hospital for construction and ceiling tile removal.

3.4 SYSTEM STARTUP AND FINISHING

A. The Contractor is responsible to work with the Owner to adjust system settings and requirements to the Owner's preferences.
B. The System Supplier shall coordinate with the Purchaser system preferences and setup. The System Supplier shall review with the Purchaser and provide the following services at a minimum:
    1. Assistance in developing the protocol policies for the Purchaser’s use of the system.
    2. Review of information and standards regarding regulations of OSHA, NACCLS, and CDC for transport of hazardous materials in the system.

3. A decontamination/infection control procedure and a cleanout kit with procedures for cleaning liquid spills in the system.
4. Containment and immobilization of items transported in the system.
5. Station carrier arrival preferences including the use of the carrier arrival chime.
6. The System Supplier shall coordinate the quick key preferences for each of the stations. The System Supplier is responsible to fully setup each of the station features to the Purchasers preferences.
7. The System Supplier shall print and install station directories at each of the stations in the system.
8. The System Supplier shall meet with the Purchaser to setup station priorities and adjust the system accordingly.
9. The System Supplier shall set carrier counts per the Purchasers preferences and distribute carriers accordingly.

3.5 SYSTEM TESTING AND ACCEPTANCE

A. General Testing
1. The pneumatic tube contractor will correct any workmanship or performance criteria not in conformance with these specifications.
2. Testing shall be performed upon completion of the enabling project.
3. The testing of the system shall be performed as follows:
   a. Factory pre-testing
   b. System Contractor testing
   c. Owner 's acceptance testing
   d. Performance testing
   e. Reliability testing
4. All equipment required for the testing shall be provided by the Contractor including:
   a. A carrier that is filled to seven (7) lbs. shall be provided for testing.
   b. The Contractor shall provide test carriers for the Contractor testing and Owner acceptance testing. Carriers utilized for these tests shall be of the same size and type as the carriers provided as part of this section. Test carriers used for these tests shall not be provided to the Owner to fulfill the new carrier requirements for the system.
5. Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion of installation and testing of the installed system. Each test report shall include the test plan and the results.
6. The performance test shall include an electronic snapshot of the traffic during the peak load test.

B. Factory Pre-testing
1. All equipment is to be factory pre-tested before being shipped to the site. The Owner may request to witness factory pre-testing of the equipment.

C. System Contractor testing

1. Perform all startup and testing requirements recommended by the manufacturer. Provide documentation of all testing performed.
2. Perform preliminary tests, verifying all components are in fully operational condition for carrier dispatch and receive between all possible station combinations.
3. Each new station in the system shall successfully send a minimum of twenty-five (25) carriers and receive a minimum of twenty-five (25) carriers. Providing that all possible station combinations have been fully tested, carriers can be sent back to the same station to fulfill this requirement. Provide a computer printout indicating the testing volume requirements.
4. All tube in the system shall transport sufficient carriers through the system to collect the majority of the metal shards and dust particles in the tube. The wear bands on each carrier shall be cleaned after each use to minimize the reintroduction of metal shards and dust particles into the system. If the metal shards and dust particles are excessive, the Purchaser or Purchaser's representative may choose to have the system cleaned at the System Suppliers cost.

D. Owner Acceptance Testing
1. In the presence of the Purchaser or Purchaser's representative, the System supplier shall perform operational tests, conduct tests of material, and review workmanship and function to establish that the work has been executed according to these specifications. The System suppliers test plan, record drawings and coordination documents shall be available on-site at the time of testing.
2. In the presence of the Purchaser or Purchaser's representative the following tests shall be demonstrated:
    a. Demonstrate that a seven (7) lb. carrier can successfully be dispatched unassisted and received with soft delivery at each station. The Purchaser may choose to evaluate the passage of the seven (7) lb. carrier through transfer units and interchange equipment.
    b. Demonstrate that an empty carrier can successfully be dispatched unassisted and received with soft delivery at each station.
3. All carriers will be evaluated for lacerations, scratches, and abrasions that are caused due to misalignment of equipment or improper installation of pipe.
4. All test carriers shall be examined for cleanliness of the system.

E. Performance Testing
1. Demonstrate that the system performance is sufficient to completely process each of the transactions from the peak hour matrix in a one-hour period. Each station shall send transactions to each of the receiving stations identified on the peak-hour matrix. The system shall have the capacity to completely process the transactions in a one (1) hour period. All stations are to send carriers simultaneously as described in the traffic matrix. The System Supplier may assign dispatch times for the carriers as part of the testing plan; however, execution of the dispatch times does not eliminate the need for the system to completely process all specified transactions during the peak-hour period.

2. Test shall include a half hour pre-test meeting with System Supplier personnel and Purchaser personnel to review the testing procedures and protocols.
3. The System Supplier is responsible to provide sufficient simulations and engineering to ensure that the system is capable of processing the peak-load carriers. If the system fails the peak-load testing, the System Supplier shall make the necessary adjustments to successfully carry out a second test. If the System Supplier cannot successfully carry out the peak-load test, the System Supplier will be responsible to bear the cost of additional testing.
4. Submit test plan and procedures, not later than thirty (30) days prior to the start of testing. The test plan and test procedures shall explain in detail, step-by-step, actions and expected results to demonstrate compliance with the requirements of this specification including the necessary conditions of operation to demonstrate performance of the system.
5. Test shall be conducted in accordance with the approved test procedures to determine that the system is functional, operational and installed in accordance with the specifications.
    a. It is estimated that the System Supplier shall provide a minimum of one (1) person to monitor the control center, one (1) person to help carry out the test. The vendor shall coordinate with the owner additional man-power to effectively carry out the test.

F. Reliability Testing
1. Reliability testing is an ongoing evaluation over the course of the first six (6) months of the system use to evaluate the reliability of the system.
2. The system shall meet the following reliability measures during the first six (6) months of system use.
    a. System downtime shall not exceed one percent (1%) of the total operating time. System downtime is defined as the amount of time that a station is ineligible to receive carriers due to a malfunction of the system. If multiple stations are down due to interchange or transfer unit malfunction, each station will be considered independently. The total hours of station operation compared against the total hours of station downtime will be the basis of the ratio for the system.
    b. A log of all system malfunctions shall be maintained by the Contractor during the service period. At the end of the six (6) month period, a report shall indicate that there shall be no more than one (1) malfunction per every thousand (1000) transactions. A malfunction is defined as equipment or system failure as a result of incorrect installation or maintenance.
3. The Contractor shall provide a printout at the end of the first month, third month and sixth month of official system use. The report shall indicate the system downtime and the number of malfunctions per number of transactions.

3.6 TRAINING

A. General Training
1. All training sessions are subject to be recorded by the Owner.

2. Operational and Maintenance Manuals are to be available during the training sessions.

B. Operator training
1. The Contractor shall train key Owner's training staff on-site in the use and operation of the system for a minimum of eight (8) hours. The Contractor shall provide sufficient training sessions to accommodate the variable staff schedules.
2. The training shall include:
   a. A commercially prepared video describing the system and its capabilities and potential benefits.
   b. Review of common system alarms and their correction.
   c. Use and functions of the system.
   d. Package of training materials for the Owner’s trainers to use.

C. Maintenance training
1. Maintenance and trouble-shooting of the system.
2. The Contractor shall train key Owner's staff on-site in the operation and maintenance of the system for a minimum of sixteen (16) hours. The Contractor shall provide sufficient training sessions to accommodate the variable staff schedules.
3. The Owner shall assign at least two (2) persons to accompany Contractor start-up technicians during final system checkout procedures.
4. Provide training for two (2) system maintenance staff in the training center. Training shall sufficiently cover the proper maintenance and troubleshooting for the equipment.

END OF SECTION 149200

SECTION 210513 - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V. and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 210513

SECTION 210517 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.

B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anticorrosion coated or galvanized, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.

F. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

G. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Jay R. Smith Mfg. Co.
2. Zurn Industries, LLC.

B. Description: Manufactured, Dura-coated or Duco-coated cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

C. Plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Non-shrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, non-sag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, Use NT.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Dow Corning Corporation.
b. GE Construction Sealants; Momentive Performance Materials Inc.
c. Polymeric Systems, Inc.
d. Schnee-Morehead, Inc., an ITW company.
e. Sherwin-Williams Company (The).

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Use silicone sealant to seal around the outside of stack-sleeve fittings.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- or smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Steel pipe sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Steel pipe sleeves.

5. Interior Partitions:

    a. Piping Smaller Than NPS 6: Steel pipe sleeves.
    b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 210517

SECTION 210518 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. Mid-America Fittings, Inc.
6. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
c. Insulated Piping: One-piece steel with polished, chrome-plated finish.
d. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
e. Insulated Piping: One-piece cast brass with polished, chrome-plated finish.
f. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
g. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
h. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
i. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
j. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
k. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.

l. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
m. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
n. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
o. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
p. Bare Piping in Unfinished Service Spaces: One-piece cast brass with polished, chrome-plated finish.
q. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
r. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
s. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.
t. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Piping: One-piece, floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 210518

SECTION 210523 - GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Two-piece ball valves with indicators.
2. Bronze butterfly valves with indicators.
3. Iron butterfly valves with indicators.
4. Check valves.
5. Bronze OS&Y gate valves.
6. Iron OS&Y gate valves.
7. NRS gate valves.
8. Indicator posts.
9. Trim and drain valves.

1.2 DEFINITIONS

A. OS&Y: Outside screw and yoke.

B. SBR: Styrene-butadiene rubber.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

1. Fire Main Equipment: HAMV - Main Level.

    a. Indicator Posts, Gate Valve: HCBZ - Level 1.
    b. Ball Valves, System Control: HLUG - Level 3.
    c. Butterfly Valves: HLXS - Level 3.
    d. Check Valves: HMER - Level 3.
    e. Gate Valves: HMRZ - Level 3.

2. Sprinkler System and Water Spray System Devices: VDGT - Main Level.

    a. Valves, Trim and Drain: VQGU - Level 1.

B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:

1. Automated Sprinkler Systems:

    a. Indicator posts.
    b. Valves.

        1) Gate valves.
        2) Check valves
        3) Miscellaneous valves.

C. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B31.9 for building services piping valves.

D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

E. NFPA Compliance for valves:

1. Comply with NFPA 13, NFPA 14, NFPA 20, and NFPA 24.

F. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher, as required by system pressures.

G. Valve Sizes: Same as upstream piping unless otherwise indicated.

H. Valve Actuator Types:

1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.3 TWO-PIECE BALL VALVES WITH INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ames Fire & Waterworks; A Watts Water Technologies Company.
2. NIBCO INC.
3. Victaulic Company.

B. Description:

1. UL 1091, except with ball instead of disc and FM Global approved for indicating valves (butterfly or ball type), Class Number 1112.
2. Minimum Pressure Rating: 350 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.4 BRONZE BUTTERFLY VALVES WITH INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ALEUM USA.
2. Globe Fire Sprinkler Corporation.

3. Milwaukee Valve Company.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
2. Minimum: Pressure rating: 350 psig.
3. Body Material: Bronze.
4. Seat Material: EPDM.
5. Stem Material: Bronze or stainless steel.
6. Disc: Stainless steel.
7. Actuator: Worm gear.
8. Supervisory Switch: Internal or external.
9. Ends Connections for Valves NPS 1 through NPS 2: Threaded ends.
10. Ends Connections for Valves NPS 2-1/2: Grooved ends.

2.5 IRON BUTTERFLY VALVES WITH INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ALEUM USA.
2. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
3. Globe Fire Sprinkler Corporation.
4. Kennedy Valve Company; a division of McWane, Inc.
5. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
6. Victaulic Company.
7. Zurn Industries, LLC.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 350 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, and EPDM or SBR coated.
7. Actuator: Worm gear.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug or wafer.

2.6 CHECK VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ames Fire & Waterworks; A Watts Water Technologies Company.
2. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
3. FEBCO; A WATTS Brand.
4. Fire Protection Products Inc (FPPI); a brand of Anvil International and Smith-Cooper International.
5. Globe Fire Sprinkler Corporation.
6. Mueller Co. LLC; Mueller Water Products, Inc.
7. Reliable Automatic Sprinkler Co., Inc. (The).
8. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
9. Victaulic Company.
10. Viking Group Inc.
11. WATTS; A Watts Water Technologies Company.
12. Zurn Industries, LLC.

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 350 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.7 BRONZE OS&Y GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Milwaukee Valve Company.
2. United Brass Works, Inc.
3. Zurn Industries, LLC.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y-type gate valves).
2. Minimum Pressure Rating: 350 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.
7. Packing: Non-asbestos PTFE.
8. End Connections: Threaded.

2.8 IRON OS&Y GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Cast Iron Pipe Company.
2. Clow Valve Company; a subsidiary of McWane, Inc.
3. Hammond Valve.
4. Mueller Co. LLC; Mueller Water Products, Inc.
5. Victaulic Company.
6. WATTS; A Watts Water Technologies Company.
7. Zurn Industries, LLC.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y-type gate valves).
2. Minimum Pressure Rating: 350 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged.

2.9 INDICATOR POSTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Cast Iron Pipe Company.
2. Clow Valve Company; a subsidiary of McWane, Inc.
3. Mueller Co. LLC; Mueller Water Products, Inc.

B. Description:

1. Standard: UL 789 and FM Global standard for indicator posts.
2. Type: Upright.
3. Base Barrel Material: Cast or ductile iron.
4. Extension Barrel: Cast or ductile iron.
5. Cap: Cast or ductile iron.
6. Operation: Wrench.

2.10 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    b. Fire Protection Products Inc (FPPI); a brand of Anvil International and Smith-Cooper International.
    c. Fire-End & Croker Corporation.
    d. Milwaukee Valve Company.
    e. Potter Roemer LLC; a Division of Morris Group International.
    f. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    g. Victaulic Company.
    h. WATTS; A Watts Water Technologies Company.
    i. Zurn Industries, LLC.

2. Description:

    a. Pressure Rating: 350 psig.
    b. Body Design: Two piece.
    c. Body Material: Forged brass or bronze.
    d. Port size: Full or standard.
    e. Seats: PTFE.
    f. Stem: Bronze or stainless steel.
    g. Ball: Chrome-plated brass.
    h. Actuator: Handlever.
    i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
    j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Fire Protection Products Inc (FPPI); a brand of Anvil International and Smith-Cooper International.
    b. United Brass Works, Inc.

2. Description:

    a. Pressure Rating: 350 psig.
    b. Body Material: Brass or bronze.
    c. Ends: Threaded.
    d. Stem: Bronze.
    e. Disc: Bronze.
    f. Packing: Asbestos free.
    g. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION, GENERAL

A. Comply with requirements in the following Sections for specific valve-installation requirements and applications:

1. Section 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.
2. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
3. Section 211316 "Dry-Pipe Sprinkler Systems" for application of valves in dry-pipe, fire-suppression sprinkler systems.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply, except from fire-department connections. Install permanent identification signs, indicating portion of system controlled by each valve.

C. Install double-check valve assembly in each fire-protection water-supply connection.

D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the pipe center.

F. Install valves in position to allow full stem movement.

G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in

which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

END OF SECTION 210523

SECTION 210529 - HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal hanger-shield inserts.
5. Fastener systems.
6. Equipment supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

C. NFPA Compliance: Comply with NFPA 13.

D. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.3 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out,

tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Cooper B-line; brand of Eaton, Electrical Sector.
    b. Hilti, Inc.
    c. ITW Ramset/Red Head; Illinois Tool Works, Inc.
    d. MKT Fastening, LLC.

2. Indoor Applications: Zinc-coated or Stainless steel.
3. Outdoor Applications: Stainless steel.

2.4 EQUIPMENT SUPPORTS

A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.5 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout, suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

D. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

F. Install lateral bracing with pipe hangers and supports to prevent swaying.

G. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

H. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.3 INSTALLATION OF EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup:

1. Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

    a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

2. Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099123 "Interior Painting."

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with NFPA requirements for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use carbon-steel pipe hangers and supports and attachments for general service applications.

E. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

F. Use thermal hanger-shield inserts for insulated piping and tubing.

G. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

H. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

I. Hanger-Rod Attachments: Comply with NFPA requirements.

J. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. C-Clamps (MSS Type 23): For structural shapes.
3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

K. Saddles and Shields: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

L. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 210529

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Pipe-riser resilient supports.
5. Resilient pipe guides.
6. Elastomeric hangers.
7. Snubbers.
8. Restraint channel bracings.
9. Seismic-restraint accessories.
10. Mechanical anchor bolts.
11. Adhesive anchor bolts.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
    d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: C.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.

    a. Component Importance Factor: 1.5.
    b. Component Response Modification Factor: 2.5.
    c. Component Amplification Factor: 1.0.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 12.64%g.
4. Design Spectral Response Acceleration at 1.0-Second Period: 9.63%g.
5. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES.

a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Ace Mountings Co., Inc.
    b. Isolation Technology, Inc.
    c. Kinetics Noise Control, Inc.
    d. Mason Industries, Inc.
    e. NOVIA; a division of Carpenter & Paterson.
    f. Vibration Eliminator Co., Inc.
    g. Vibration Isolation.
    h. Vibration Management Corp.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Smooth pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.

    a. Surface Pattern: Smooth pattern.
    b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Ace Mountings Co., Inc.
    b. Isolation Technology, Inc.
    c. Mason Industries, Inc.
    d. NOVIA; a division of Carpenter & Paterson.
    e. Vibration Eliminator Co., Inc.
    f. Vibration Isolation.
    g. Vibration Management Corp.

2. Mounting Plates:

   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ace Mountings Co., Inc.
   b. Isolation Technology, Inc.
   c. Mason Industries, Inc.
   d. NOVIA; a division of Carpenter & Paterson.
   e. VMC GROUP.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Management Corp.

2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

   a. Housing: Cast-ductile iron or welded steel.
   b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.6 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post-and-sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.7 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ace Mountings Co., Inc.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. NOVIA; a division of Carpenter & Paterson.
   e. Vibration Eliminator Co., Inc.
   f. Vibration Isolation.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.8 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. VMC GROUP.
4. Vibration Management Corp.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.

3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.9 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.10 SEISMIC-RESTRAINT ACCESSORIES

A. Retain "Hanger-Rod Stiffener" Paragraph below for strengthening resistance of hanger rods against seismic forces that may cause buckling of rods; delete if detailed on Drawings. Use with either channel- or cable-type bracing assemblies when required to counter seismic forces. Detail fabrication and indicate locations on Drawings.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.11 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-line; brand of Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Powers Fasteners.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of equipment supports and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on fire-suppression equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

F. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

END OF SECTION 210548

SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.

D. Valve Schedules: Valve numbering scheme.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.

b. Brimar Industries, Inc.
c. Carlton Industries, LP.
d. Craftmark Pipe Markers.
e. Marking Services, Inc.
f. Seton Identification Products.

2. Material and Thickness: Brass, 0.032 inch thick, with predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Champion America.
d. Craftmark Pipe Markers.
e. Seton Identification Products.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
8. Fasteners: Stainless-steel self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Craftmark Pipe Markers.
3. Marking Sevices Inc.
4. National Marker Company.
5. Seton Identification Products.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.

C. Letter Color: Red.

D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

H. Fasteners: Stainless-steel self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Carlton Industries, LP.

3. Champion America.
4. Craftmark Pipe Markers.
5. Marking Sevices Inc.
6. Seton Identification Products.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

F. Pipe-Label Colors:

1. Background Color: Safety Red.
2. Letter Color: White.

2.4 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Carlton Industries, LP.
3. Champion America.
4. Craftmark Pipe Markers.
5. Marking Sevices Inc.
6. Seton Identification Products.

B. Description: Stamped or engraved with 1/4-inch letters for piping-system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032 inch thick, with predrilled holes for attachment hardware.
2. Fasteners: Brass beaded chain.
3. Valve-Tag Color: Safety Red.
4. Letter Color: White.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Champion America.
4. Craftmark Pipe Markers.
5. Seton Identification Products.

B. Description: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping: Painting of piping is specified in Section 099123 "Interior Painting."

B. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit a view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:

1. Valve-Tag Size and Shape:

a. Fire-Suppression Standpipe: 1-1/2 inches, round.
b. Wet-Pipe Sprinkler System: 1-1/2 inches, round.
c. Dry-Pipe Sprinkler System: 1-1/2 inches, round.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 210553

SECTION 210800 - COMMISSIONING OF FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify Division 21 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in Section 019113.

C. Commissioning requires the participation of Division 21 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Division 1. Division 21 shall be familiar with all parts of Division 1 and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 019113 – Commissioning Requirements.

B. Section 019114 – Installation Verification Procedures

C. Section 019115 – Functional Test Procedures

D. Section 017913 – Demonstration and Training Requirements

1.3 SUBMITTALS

A. Refer to Division 01 and Section 019113 for commissioning submittal requirements. Provide copies of commissioning submittal requirement to the CxA in addition to copies required by the Owner and Design Professional.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 21 shall provide all testing equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 019113 for additional equipment requirements.

PART 3 - EXECUTION

3.1 COMMISSIONING

A. General Requirements: For additional information regarding general commissioning requirements refer to Section 019913.

B. Installation contractors shall be responsible for executing and documenting equipment installation, startup and check out of systems and equipment prior to CxA scheduling the functional performance tests. Contractor shall be responsible for providing training of the Owner's maintenance personnel in accordance with requirement of Division 01.

C. Installation verification checklist for the commissioned systems and equipment shall be provided to the installation contractors by the CxA for use by the contractor in documenting the installation and startup of equipment in the commissioning process.

D. For systems and equipment components requiring a manufacturer’s representative for installation and startup, the installing contractor is responsible for attaching the startup report to the IVC provided by the CxA.

E. TAB reports required for the fire protection systems shall be provided to the CxA before functional testing is started.

3.2 GENERAL RESPONSIBILITIES

A. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors in regard to Division 21 are as follows

1. Include the cost of commissioning in the contract price.
2. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data, and training.
3. Ensure acceptable representation with the means and authority to assist the CxA in the coordination and execution of the commission process.
4. Attend a commissioning scoping meeting and other meetings necessary to facilitate the Commissioning process.
5. Review commissioning plan to be provided by the CxA.
6. Assist CxA with developing a comprehensive commissioning schedule during regularly scheduled commissioning meetings.
7. Complete commissioning activities as schedule in the master construction schedule.
8. Submit completed IVC checklists and supporting documents to PM/CM. The contractor with primary responsibility to provide and install the system or equipment is responsible for ensuring that other contractors involved with the installation complete their portion of the checklist.
9. Ensure that installation and startup are complete and the system or equipment are ready for functional testing.
10. Utilize the FPT protocols to retest the system or equipment prior to actual function performance testing. Provide documentation to CxA that pretesting was performed.
11. Address current A/E punch list items before functional testing.
12. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

13. Provide skilled technicians to perform functional performance testing under the direction of the Commissioning Authority.
14. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, OPM and A/E and retest the equipment.
15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to record conditions.
16. Provide training of the Owner's maintenance and operating staff using expert qualified personnel, as specified.
17. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3.3 CONTROL CONTRACTOR RESPONSIBILITIES

A. Additional commissioning responsibilities of the controls contractor, during construction acceptance and warrant phases are:

1. Include monitoring and control of fire protection systems and equipment in the control drawing submittals
2. Complete the installation and thoroughly inspect, startup, test, adjust, calibrate, and document systems, equipment devices, sensors, etc., to be connected or controlled by the building automation system. Provide documented point-to-point check out of the control system prior to functional performance testing of fire protection systems.
3. Assist and cooperate with the CxA in the following manner:

    a. Using a skilled technician who is familiar with this building, execute the functional testing of the controls system.
    b. Assist in the functional testing of all commissioned equipment.
    c. Provide two-way radios during the testing.
    d. Execute all control system trend logs.

4. Complete IVC checklists and submit with supporting documentation.

3.4 TAB CONTRACTOR RESPONSIBLITIES

A. Additional responsibilities of the TAB contractor are:

1. Provide the PM/CM CxA a draft TAB report within two weeks of completion.
2. Provide the PM/CM CxA a draft TAB report within two weeks of completion.
3. Provide the CxA with any requested data, gathered, but not shown on the draft reports.
4. Provide a final TAB report for to the PM/CM CxA.

3.5 TRAINING

A. Refer to Division 01 for demonstration and Training requirements.

B. The PM/CM shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

C. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems.

D. Provide the Commissioning Authority with a training plan six weeks before the planned training.

E. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

F. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

G. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment.

END OF SECTION

SECTION 211119 – FIRE DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Exposed-type fire-department connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each fire-department connection.

PART 2 - PRODUCTS

2.1 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Fire Hose & Cabinet.
2. Elkhart Brass Mfg. Co., Inc.
3. Fire Protection Products Inc (FPPI); a brand of Anvil International and Smith-Cooper International.
4. Fire-End & Croker Corporation.
5. Guardian Fire Equipment, Inc.

B. Standard: UL 405.

C. Type: Exposed, projecting, for wall mounting.

D. Pressure Rating: 175 psig minimum.

E. Body Material: Corrosion-resistant metal.

F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

G. Caps: Brass, lugged type, with gasket and chain.

H. Escutcheon Plate: Round, brass, wall type.

I. Outlet: Back, with pipe threads.

J. Number of Inlets: Two.

K. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."

L. Finish: Rough brass or bronze.

M. Outlet Size: NPS 6.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.

B. Examine roughing-in for fire-suppression standpipe system to verify actual locations of piping connections before fire-department connection installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-type fire-department connections.

B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 211119

SECTION 211200 - FIRE-SUPPRESSION STANDPIPES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection specialty valves.
3. Hose connections.
4. Alarm devices.
5. Manual control stations.
6. Control panels.
7. Pressure gages.

1.3 DEFINITIONS

A. High-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure higher than standard 300 psig, but not higher than 350 psig.

B. Standard-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure 175 psig maximum.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fire-suppression standpipes.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For standpipe systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fire-suppression standpipes, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Domestic water piping.
2. Compressed-air piping.
3. HVAC hydronic piping.
4. Nitrogen piping.

B. Qualification Data: For Installer and professional engineer.

C. Approved Standpipe Drawings: Working plans, prepared according to NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

D. Welding certificates.

E. Fire-hydrant flow test report.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-suppression standpipes specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Fire-Suppression Standpipe Service: Do not interrupt fire-suppression standpipe service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fire-suppression standpipe service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of fire-suppression standpipe service.
2. Do not proceed with interruption of fire-suppression standpipe service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

A. Automatic Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.

2.2 PERFORMANCE REQUIREMENTS

A. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig minimum working pressure.

B. High-Pressure, Fire-Suppression Standpipe System Component: Listed for 350-psig working pressure.

C. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

D. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.

1. Minimum residual pressure at each hose-connection outlet is as follows:
   a. NPS 2-1/2 Hose Connections: 100 psig.

E. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.3 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials and for joining methods for specific services, service locations, and pipe sizes.

2.4 BLACK STEEL PIPE AND ASSOCIATED FITTINGS

A. Schedule 40: ASTM A 53/A 53M, Type E, Grade B; with factory- or field-formed ends to accommodate joining method.

B. Schedule 10: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

C. Uncoated, Steel Couplings: ASTM A 865/A 865M, threaded.

D. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

E. Malleable- or Ductile-Iron Unions: UL 860.

F. Cast-Iron Flanges: ASME B16.1, Class 125.

G. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

H. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

I. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
    b. CPS Products, Inc.
    c. National Fittings, Inc.
    d. Shurjoint; a part of Aalberts Integrated piping Systems.
    e. Smith-Cooper International.
    f. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    g. Victaulic Company.

2. Pressure Rating: 350 psig minimum.
3. Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.6 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
2. Pressure Rating:

a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
b. High-Pressure Piping Specialty Valves: 350 psig.

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Globe Fire Sprinkler Corporation.
b. Reliable Automatic Sprinkler Co., Inc. (The).
c. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
d. Victaulic Company.
e. Viking Group Inc.

2. Standard: UL 193.
3. Design: For horizontal or vertical installation.

4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
5. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
6. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

C. Pressure-Reducing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. CLA-VAL.
    b. Elkhart Brass Mfg. Co., Inc.
    c. Fire-End & Croker Corporation.
    d. Guardian Fire Equipment, Inc.
    e. OCV Control Valves.
    f. Potter Roemer LLC; a Division of Morris Group International.
    g. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    h. Victaulic Company.
    i. Zurn Industries, LLC.
2. UL 668 hose valve, with integral UL 1468 reducing device.
3. Pressure Rating: 350 psig minimum.
4. Material: Brass or bronze.
5. Inlet: Female pipe threads.
6. Outlet: Threaded with or without adapter having male hose threads.
7. Pattern: Angle.
8. Finish: Rough brass or bronze.

D. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Reliable Automatic Sprinkler Co., Inc. (The).
    b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.

2. Standard: UL 1726.
3. Pressure Rating: 175 psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.7 HOSE CONNECTIONS

A. Adjustable-Valve Hose Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brooks Equipment Co., Inc.
    b. Elkhart Brass Mfg. Co., Inc.
    c. Potter Roemer LLC; a Division of Morris Group International.
    d. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    e. Zurn Industries, LLC.

2. Standard: UL 668 hose valve, with integral UL 1468 reducing or restricting pressure-control device, for connecting fire hose.
3. Pressure Rating: 350 psig minimum.
4. Material: Brass or bronze.
5. Size: NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle.
9. Pressure-Control Device Type: Pressure reducing.
10. Finish: Rough brass or bronze.

B. Nonadjustable-Valve Hose Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brooks Equipment Co., Inc.
    b. Elkhart Brass Mfg. Co., Inc.
    c. Potter Roemer LLC; a Division of Morris Group International.
    d. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    e. Zurn Industries, LLC.

2. Standard: UL 668 hose valve for connecting fire hose.
3. Pressure Rating: 350 psig minimum.
4. Material: Brass or bronze.
5. Size: NPS 1-1/2 or NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle.
9. Finish: Rough brass or bronze.

2.8 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ADT Security Services, Inc.
    b. ITT McDonnell & Miller.
    c. Potter Electric Signal Company, LLC.
    d. System Sensor.
    e. Viking Group Inc.
    f. WATTS; A Watts Water Technologies Company.

2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 350 psig.
7. Design Installation: Horizontal or vertical.

C. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Fire-Lite Alarms; Honeywell International, Inc.
    b. Kennedy Valve Company; a division of McWane, Inc.
    c. Potter Electric Signal Company, LLC.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.9 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK, Inc.
2. Ashcroft Inc.
3. Brecco Corporation.
4. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: Zero to 350 psig.

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.

C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install drain valves on standpipes. Extend drain piping to outside of building.

F. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

G. Install pressure gages on riser or feed main and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.

H. Drain dry-type standpipe system piping.

I. Fill wet-type standpipe system piping with water.

J. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

K. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

L. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

I. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

3.6 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install NPS 2-1/2 hose connections with quick-disconnect and flow-restricting device.

3.7 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 14.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire-department equipment.

C. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.10 PIPING SCHEDULE

A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded joints.

B. Standard-pressure, wet-type fire-suppression standpipe piping, NPS 4 and smaller, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Schedule 10, black-steel pipe with plain ends; welding fittings; and welded joints.

C. Standard-pressure, wet-type fire-suppression standpipe piping, NPS 5 to NPS 8, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

2. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Schedule 10, black-steel pipe with plain ends; welding fittings; and welded joints.

D. High-pressure, wet-type fire-suppression standpipe piping, NPS 4 and smaller, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10, black-steel pipe with plain ends; welding fittings; and welded joints.

E. High-pressure, wet-type fire-suppression standpipe piping, NPS 5 and larger, shall be one of the following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10, black-steel pipe with plain ends; welding fittings; and welded joints.

END OF SECTION 211200

SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Specialty valves.
3. Air vent.
4. Sprinkler piping specialties.
5. Sprinklers.
6. Alarm devices.
7. Manual control stations.
8. Control panels.
9. Pressure gauges.
10. Nitrogen Injection Ports.
11. Automatic Nitrogen Inerting Vents.
12. Corrosion Monitoring Station.

1.2 DEFINITIONS

A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 300 psig, but not higher than 350 psig.

B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data, signed, and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler system plans and sections, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Qualification Data: For qualified Installer and NICET certified technician.

C. Design Data: Approved sprinkler piping working plans, prepared according to NFPA 13, including documented approval by authorities having jurisdiction, and including hydraulic calculations if applicable.

D. Welding certificates.

E. Field Test Reports:

1. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
2. Fire-hydrant flow test report.

F. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.8 FIELD CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of sprinkler service.
2. Do not proceed with interruption of sprinkler service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Sprinkler system equipment, specialties, accessories, installation, and testing to comply with NFPA 13.

C. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

D. High-Pressure Piping System Component: Listed for 350-psig minimum working pressure.

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:

a. Offices, Lounges, Conference Rooms, Classrooms, Separated Dining Areas, Atriums, Auditoriums, Lobbies, Toilet Rooms, Corridors, Common Areas, Public Areas, Core Areas: Light Hazard. Density: 0.10 GPM/sq. ft. Area: 1500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Area

Per Sprinkler Head:196 sq. ft. with Finished ACT Ceiling Tiles, 225 sq. ft. with Finished GWB Ceilings

b. Patient Rooms, Exam Rooms, Procedure Rooms, Operating Rooms, Clinical Spaces: Light Hazard. Density: 0.10 GPM/.sq. ft. Area: 1500 sq. ft. Hose Demand: 100 GPM. Maximum Protection Area Per Sprinkler Head: 196 sq. ft. with Finished ACT ceiling Tiles, 225 sq. ft. with Finished GWB Ceilings.

c. Shell Spaces for Future Infills or Tenants: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area 1500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Per Sprinkler Head: 130 sq. ft.

d. Shell Spaces for Future Laboratory/Tenant Infill and/or Retail: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 1500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Per Sprinkler Head: 130 sq. ft.

e. Mechanical, Electrical, Retail, Classes I to IV Commodities Storage up to 200 sq. ft., Workshop and Utility Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Area Per Sprinkler Head: 130 sq. ft.

f. Laboratories, Lab Support Areas, Glass Wash, Cage Wash, Pharmacy and Vivarium Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Areas Per Sprinkler Head: 130 sq. ft.

g. Flammable Gas Storage Areas: Extra Hazard Group 1. Density: 0.30 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection area Per Sprinkler Head: 100 sq. ft.

h. Kitchen and Server Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Per Sprinkler Head: 130 sq. ft.

i. Storage and Receiving Areas: Extra Hazard Group 2 and NFPA 13 Storage Criteria. Density: Refer to FM Data Sheet 8-9, Area: 500 sq. ft. Hose Demand: 100 GPM. Maximum Protection Area Per Sprinkler Head 11.2.

j. Fuel Oil Storage: Extra Hazard Group 2. Density: 0.40 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 500 GPM. Maximum Protection Area Per Sprinkler Head: 100 GPM.

k. Parking Garages, Vehicle Parking, Ramp and Driveway Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 3500 sq. ft. Hose Demand 250 GPM. Maximum Protection Area Per Sprinkler Head: 130 sq. ft.

l. Transformer Vault: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 3500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Area Per Sprinkler Head: 130 sq. ft.

m. Generator Rooms: Extra Hazard Group 1. Density: 0.30 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 500 GPM. Maximum Protection Area Per Sprinkler Head: 100 sq. ft.

F. Obtain documented approval of sprinkler system design from authorities having jurisdiction.

G. Seismic Performance: Sprinkler piping to withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

2.2 STEEL PIPE AND FITTINGS

A. Standard-Weight Steel Pipe: black-steel pipe, ASTM A53/A53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

C. Steel Pipe Nipples: black steel, ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

D. Steel Couplings: uncoated steel, ASTM A865/A865M, threaded.

E. Gray-Iron Threaded Fittings: uncoated gray-iron threaded fittings, ASME B16.4, Class 125, standard pattern.

F. Malleable- or Ductile-Iron Unions: UL 860.

G. Cast-Iron Flanges: ASME 16.1, Class 125.

H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or EPDM rubber gasket.

    a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
    b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.

I. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
    b. CPS Products, Inc.
    c. National Fittings, Inc.
    d. Shurjoint; a part of Aalberts Integrated piping Systems.
    e. Smith-Cooper International.
    f. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    g. Victaulic Company.

2. Pressure Rating: 350-psig minimum.
3. Grooved-End Fittings for Steel Piping: Painted grooved-end fittings, ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating:

1. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
2. High-Pressure Piping Specialty Valves: 350 psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Alarm Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Globe Fire Sprinkler Corporation.
b. Reliable Automatic Sprinkler Co., Inc. (The).
c. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
d. Victaulic Company.
e. Viking Group Inc.

2. Standard: UL 193.
3. Design: For horizontal or vertical installation.
4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, retarding chamber, and fill-line attachment with strainer.
5. Drip cup assembly pipe drain with check valve to main drain piping.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Deluge Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CLA-VAL.
b. Globe Fire Sprinkler Corporation.
c. Kidde; Carrier Global Corporation.
d. Reliable Automatic Sprinkler Co., Inc. (The).
e. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
f. Victaulic Company.
g. Viking Group Inc.

2. Standard: UL 260.
3. Design: Hydraulically operated, differential-pressure type.
4. Include trim sets for alarm-test bypass, drain, electrical water-flow alarm switch, pressure gauges, drip cup assembly piped without valves and separate from main drain line, and fill-line attachment with strainer.
5. Wet, Pilot-Line Trim Set: Include gauge to read diaphragm-chamber pressure and manual control station for manual operation of deluge valve, and connection for actuation device.

H. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Reliable Automatic Sprinkler Co., Inc. (The).
b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.

2. Standard: UL 1726.
3. Pressure Rating: 350 psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.4 AIR VENT

A. Manual Air Vent/Valve:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AGF Manufacturing, Inc.
b. National Fittings, Inc.
c. Shurjoint; a part of Aalberts Integrated piping Systems.
d. Victaulic Company.

2. Description: Ball valve that requires human intervention to vent air.
3. Body: Forged brass.
4. Ends: Threaded.
5. Minimize Size: 1/2 inch.

6. Minimum Water Working Pressure Rating: 350 psig.

2.5 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AGF Manufacturing, Inc.
    b. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
    c. National Fittings, Inc.
    d. Shurjoint; a part of Aalberts Integrated piping Systems.
    e. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    f. Victaulic Company.

2. Standard: UL 213.
3. Pressure Rating: 350 psig.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AGF Manufacturing, Inc.
    b. Reliable Automatic Sprinkler Co., Inc. (The).
    c. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    d. Victaulic Company.

2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 350 psig.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AGF Manufacturing, Inc.
b. Elkhart Brass Mfg. Co., Inc.
c. Fire-End & Croker Corporation.
d. Potter Electric Signal Company, LLC.
e. Potter Roemer LLC; a Division of Morris Group International.

2. Standard: UL 199.
3. Pressure Rating: 350 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AGF Manufacturing, Inc.
b. Triple R Specialty.
c. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
d. Victaulic Company.
e. Viking Group Inc.

2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 350 psig.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aegis Technologies, Inc.
b. CECA, LLC.
c. CPS Products, Inc.
d. Merit Manufacturing.

2. Standard: UL 1474.
3. Pressure Rating: 350 psig.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. FlexHead Industries, Inc.
   b. Victaulic Company.

2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 350 psig.
5. Size: Same as connected piping, for sprinkler.

2.6 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Globe Fire Sprinkler Corporation.
2. Reliable Automatic Sprinkler Co., Inc. (The).
3. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
4. Victaulic Company.
5. Viking Group Inc.

B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. Pressure Rating for High-Pressure Automatic Sprinklers: 350 psig.

E. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

F. Open Sprinklers with Heat-Responsive Element Removed: UL 199.

1. Nominal Orifice:

   a. 1/2 inch, with discharge coefficient K between 5.3 and 5.8.

G. Sprinkler Finishes: Chrome plated bronze and painted.

H. Special Coatings: Wax, lead, and corrosion-resistant paint.

I. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Chrome-plated steel, two-piece, with 1-inch vertical adjustment.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

J. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Reliable Automatic Sprinkler Co., Inc. (The).
b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
c. Victaulic Company.
d. Viking Group Inc.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.7 NITROGEN INERTING (Wet Pipe Systems)

A. Provide and install a nitrogen inerting system designed to prevent oxygen corrosion in the wet pipe sprinkler system.

B. Automatic Nitrogen Inerting Vents and Injection Ports:
1. Automatic nitrogen inerting vents and injection ports shall be Engineered Corrosion Solutions PAV-WN or approved equal.

C. Wet Pipe Nitrogen Inerting Start-up Kit:
1. Provide a wet pipe nitrogen inerting start-up kit which includes a 3/8” kink-resistant rubber hose, a nitrogen cylinder regulator, industrial brass couplers. Engineered Corrosion Solutions NISK-1 or approved equal.

2.8 CORROSION MONITORING STATION

A. Provide and install a corrosion monitoring station with a corrosion monitoring probe on the system’s main riser to monitor internal corrosion activity within the fire sprinkler system. Corrosion monitoring station shall be Engineered Corrosion Solutions ICMS including an Engineered Corrosion Solutions detector probe DCMP- 3 or approved owner equal.

2.9 ALARM DEVICES

A. Alarm-device types to match piping and equipment connections.

B. Electrically Operated Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Fire-Lite Alarms; Honeywell International, Inc.
   b. Notifier; Honeywell International, Inc.
   c. Potter Electric Signal Company, LLC.

2. Strobe/Horn:

   a. Standard: UL 464.
   b. Tone: Selectable, steady, Temporal-3 (T-3) in accordance with ISO 8201 and ANSI/ASA S3.41, 2400 Hz, electromechanical, broadband.
   c. Voltage: 120 V ac, 60 Hz.
   d. Effective Intensity: 110 cd.
   e. Finish: Red, suitable for outdoor use with approved and listed weatherproof backbox. White letters on housing identifying device as for "Fire."
   f. Sign, Integrated: Mount between backbox and strobe/horn with text visible on both sides, above and below strobe/horn. Housing to be shaped to cover surface-mounted weatherproof backbox. Sign is to consist of white lettering on red plastic identifying it as a "Sprinkler Fire Alarm" and instructing viewers to call 911, police, or fire department.

C. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. ADT Security Services, Inc.
   b. ITT McDonnell & Miller.
   c. Potter Electric Signal Company, LLC.
   d. Viking Group Inc.
   e. WATTS; A Watts Water Technologies Company.

2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 350 psig.
7. Design Installation: Horizontal or vertical.

D. Pressure Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Barksdale, Inc.
b. Detroit Switch, Inc.
c. Potter Electric Signal Company, LLC.
d. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
e. United Electric Controls Co.
f. Viking Group Inc.

2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Fire-Lite Alarms; Honeywell International, Inc.
b. Potter Electric Signal Company, LLC.
c. System Sensor.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.10 MANUAL CONTROL STATIONS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve.

B. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.11 CONTROL PANELS

A. Description: Single-area, two-area, or single-area cross-zoned control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves.

1. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" when used with thermal detectors and Class A detector circuit wiring.
2. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.

3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Manual Control Stations, Electric Operation: Metal enclosure, labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

C. Panel Components:

1. Power supply.
2. Battery charger.
3. Standby batteries.
4. Field-wiring terminal strip.
5. Electrically supervised solenoid valves and polarized fire-alarm bell.
6. Lamp test facility.
7. Single-pole, double-throw auxiliary alarm contacts.
8. Rectifier.

2.12 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AGF Manufacturing, Inc.
2. AMETEK, Inc.
3. Ashcroft Inc.
4. Brecco Corporation.
5. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gauge Range: 0 to 350 psig.

E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Section 331415 "Site Water Distribution Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-service piping.

3.3 INSTALLATION OF PIPING

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect/Engineer before deviating from approved working plans.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.

N. Pressurize and check preaction sprinkler system piping and air-pressure maintenance devices.

O. Fill sprinkler system piping with water.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

I. Steel-Piping, Pressure-Sealed Joints: Join steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

K. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 INSTALLATION OF VALVES AND SPECIALTIES

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
3. Install deluge valves in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.

E. Air Vent:

1. Provide at least one air vent at high point in each wet-pipe sprinkler system in accordance with NFPA 13 requirements. Connect vent into top of fire sprinkler piping.
2. Provide dielectric union for dissimilar metals, ball valve, and strainer upstream of automatic air vent.
3. Pipe from outlet of air vent to drain.

3.6 INSTALLATION OF SPRINKLERS

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.7 AUTOMATIC NITROGEN INERTING VENTS

A. General:
1. Provide an automatic nitrogen inerting vent and nitrogen injection port for each sprinkler zone and at the top of each multi-story standpipe or combination riser.
2. Device location shall be determined by This Contractor and approved by the Owner (consult with Engineered Corrosion Solutions for preferred locations).
3. Vents shall be located such that they are easily accessible and can be visually monitored from the floor. Install at the remote high point of the sprinkler zone piping.
4. Install Nitrogen Injection Port at the riser on the system side of the control valve. This Contractor shall leave the provided ball valve in the closed position after installation.
5. To initiate nitrogen inerting procedure:
    a. Completely drain the fire sprinkler system.
    b. Attach source of nitrogen gas to the Nitrogen Injection Port installed at riser.
    c. Pressurize the fire sprinkler system with nitrogen gas.
    d. Then drain the fire sprinkler system through the main drain until system pressure reads 0 PSI.
    e. Repeat nitrogen pressurization cycles until the fire sprinkler system concentration reaches 98% nitrogen or greater.
    f. Fill the fire sprinkler system with water when nitrogen inerting is complete.
    g. A Complete Nitrogen Inerting Protocol will be provided as part of Manufacturers Consulting Services Package for Commissioning.

B. Corrosion Monitoring Station:
1. Corrosion Monitoring Station shall be located downstream of the double check valve assembly not more than 5 feet above finished floor and in accordance with manufactures recommendations.

3.8 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves and pressure-maintenance pumps.

3.12 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends, cast-iron threaded fittings, and threaded joints.

B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

C. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2 and Smaller, to Be One of the Following:

1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2-1/2 to NPS 4, to Be One of the Following:

1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

E. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 5 and Larger, to Be One of the Following:

1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

F. High-Pressure, Wet-Pipe Sprinkler System, NPS 4 and Smaller, to Be One of the Following:

1. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.
2. Schedule 10 black-steel pipe with plain ends; welding fittings; and welded joints.

G. High-Pressure, Wet-Pipe Sprinkler System, NPS 5 and Larger, to Be One of the Following:

1. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.
2. Schedule 10 black-steel pipe with plain ends; welding fittings; and welded joints.

3.13 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.
5. Deluge-Sprinkler Systems: Upright and pendent, open sprinklers.
6. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted cover plate to match ceiling color.
2. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

3.14 CLOSEOUT ACTIVITIES

A. Nitrogen Generation System Commissioning.

3.15 Engage a qualified consultant for the nitrogen generation system and components to perform the following:

1. Provide recommendation regarding size of the compressor and preferred operation of the air maintenance device.
2. Provide record drawings indicating locations of air vents.
3. Provide qualified consultant on-site to direct final adjustments and operating pressures.
4. Provide a quality control kit.

5. Provide field reports.

3.16 Provide Owner's manual for system indicating system components and all necessary inspections and maintenance of components.

END OF SECTION 211313

SECTION 211316 - DRY-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Specialty valves.
3. Preaction sprinkler system nitrogen generator with purge/vent.
4. Sprinkler piping specialties.
5. Sprinklers.
6. Alarm devices.
7. Manual control stations.
8. Control panels.
9. Pressure gauges.

1.2 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Dry-pipe sprinkler system piping designed to operate at working pressure of 350 psig maximum.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For dry-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittal: For dry-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems plans and sections, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinate with all building trades.

1. Domestic water piping.
2. Compressed air piping.
3. HVAC hydronic piping.
4. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.

B. Qualification Data: For qualified Installer and NICET certified technician.

C. Design Data: Approved sprinkler piping working plans, prepared according to NFPA 13, including documented approval by authorities having jurisdiction, and including hydraulic calculations if applicable.

D. Welding certificates.

E. Field Test Reports:

1. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
2. Fire-hydrant flow test report.

F. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For dry-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.8 FIELD CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of sprinkler service.
2. Do not proceed with interruption of sprinkler service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

A. Double-Interlock Preaction Sprinkler System: Automatic sprinklers are attached to piping containing low-pressure air or nitrogen. Actuation of a fire-detection system, located in same area as sprinklers, will activate the normally closed solenoid but will not open the preaction valve. Activation of a sprinkler head will not permit water to flow into sprinkler piping. Activation of both the normally closed solenoid valve and automatic sprinkler is required to cause the preaction valve to open, permitting water to flow into sprinkler piping, and water will then discharge from opened sprinkler.

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Sprinkler system equipment, specialties, accessories, installation, and testing to comply with NFPA 13.

C. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design dry-pipe sprinkler systems.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications, Minimum Density for Automatic-Sprinkler Piping Design, Maximum Protection Area per Sprinkler, and Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:

    a. Offices, Lounges, Conference Rooms, Classrooms, Separated Dining Areas, Atriums, Auditoriums, Lobbies, Toilet Rooms, Corridors, Common Areas, Public Areas, Core Areas: Light Hazard. Density: 0.10 GPM/sq. ft. Area: 1500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Area Per Sprinkler Head:196 sq. ft. with Finished ACT Ceiling Tiles, 225 sq. ft. with Finished GWB Ceilings
    b. Patient Rooms, Exam Rooms, Procedure Rooms, Operating Rooms, Clinical Spaces: Light Hazard. Density: 0.10 GPM/.sq. ft. Area: 1500 sq. ft. Hose Demand: 100 GPM. Maximum Protection Area Per Sprinkler Head: 196 sq. ft. with Finished ACT ceiling Tiles, 225 sq. ft. with Finished GWB Ceilings.
    c. Shell Spaces for Future Infills or Tenants: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area 1500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Per Sprinkler Head: 130 sq. ft.
    d. Shell Spaces for Future Laboratory/Tenant Infill and/or Retail: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 1500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Per Sprinkler Head: 130 sq. ft.
    e. Mechanical, Electrical, Retail, Classes I to IV Commodities Storage up to 200 sq. ft., Workshop and Utility Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Area Per Sprinkler Head: 130 sq. ft.
    f. Laboratories, Lab Support Areas, Glass Wash, Cage Wash, Pharmacy and Vivarium Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Areas Per Sprinkler Head: 130 sq. ft.
    g. Flammable Gas Storage Areas: Extra Hazard Group 1. Density: 0.30 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection area Per Sprinkler Head: 100 sq. ft.
    h. Kitchen and Server Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Per Sprinkler Head: 130 sq. ft.
    i. Storage and Receiving Areas: Extra Hazard Group 2 and NFPA 13 Storage Criteria. Density: Refer to FM Data Sheet 8-9, Area: 500 sq. ft. Hose Demand: 100 GPM. Maximum Protection Area Per Sprinkler Head 11.2.
    j. Fuel Oil Storage: Extra Hazard Group 2. Density: 0.40 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 500 GPM. Maximum Protection Area Per Sprinkler Head: 100 GPM.

k. Parking Garages, Vehicle Parking, Ramp and Driveway Areas: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 3500 sq. ft. Hose Demand 250 GPM. Maximum Protection Area Per Sprinkler Head: 130 sq. ft.

l. Transformer Vault: Ordinary Hazard Group 2. Density: 0.20 GPM/sq. ft. Area: 3500 sq. ft. Hose Demand: 250 GPM. Maximum Protection Area Per Sprinkler Head: 130 sq. ft.

m. Generator Rooms: Extra Hazard Group 1. Density: 0.30 GPM/sq. ft. Area: 2500 sq. ft. Hose Demand: 500 GPM. Maximum Protection Area Per Sprinkler Head: 100 sq. ft.

E. Obtain documented approval of sprinkler system design from authorities having jurisdiction.

F. Seismic Performance: Sprinkler piping to withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

2.3 STEEL PIPE AND FITTINGS

A. Standard-Weight, Galvanized-Steel Pipe: ASTM A53/A53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

C. Galvanized-Steel Couplings: ASTM A865/A865M, threaded.

D. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

E. Malleable- or Ductile-Iron Unions: UL 860.

F. Cast-Iron Flanges: ASME B16.1, Class 125.

G. Plain-End-Pipe Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn or screwed retainer pin to secure pipe in fitting.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
b. Shurjoint; a part of Aalberts Integrated piping Systems.

H. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.

b. National Fittings, Inc.
c. Shurjoint; a part of Aalberts Integrated piping Systems.
d. Smith-Cooper International.
e. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
f. Victaulic Company.

2. Pressure Rating: 350-psig minimum.
3. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.4 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating:

1. Standard-Pressure Piping Specialty Valves: 350-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Preaction Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CLA-VAL.
b. Globe Fire Sprinkler Corporation.
c. Potter Electric Signal Company, LLC.
d. Reliable Automatic Sprinkler Co., Inc. (The).
e. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
f. Victaulic Company.
g. Viking Group Inc.

2. Standard: UL 260.
3. Design: Hydraulically operated, differential-pressure type.
4. Include trim sets for alarm-test bypass, drain, electrical water-flow alarm switch, pressure gauges, drip cup assembly piped without valves and separate from main drain line, and fill-line attachment with strainer.

5. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gauges; low-air-pressure warning switch; air relief valve; and actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.

G. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Reliable Automatic Sprinkler Co., Inc. (The).
   b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.

2. Standard: UL 1726.
3. Pressure Rating: 350-psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.5 PREACTION SPRINKLER SYSTEM NITROGEN GENERATOR WITH PURGE/VENT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Engineered Corrosion Solutions.
2. General Air Products, Inc.
3. Potter Electric Signal Company, LLC.
4. South-Tek Systems, LLC.

B. Description: Nitrogen generator system to serve preaction sprinkler zones for piping corrosion mitigation, including system venting. System is to provide required supervisory pressure within sprinkler zone. System is to include either an integrated, oil-less air compressor located within the nitrogen generator system package, or a separate vibration-isolation mounted air compressor, also provided by nitrogen generator manufacturer.

C. Standards:

1. FM Approvals 1035.
2. UL 508A listed.

D. Nitrogen Generator:

1. Wall-mounted nitrogen generator to provide minimum nitrogen purity of 98 percent to the designated sprinkler systems.

2. Power: 120 V ac.
3. Integral air compressor
4. Bypass mode and nitrogen generating mode.
5. Minimum Capacity: As recommended by manufacturer.

E. Automatic Purge Vent/Valve:

1. Vents oxygen during system nitrogen fill.
2. Automatically closes when 98 percent minimum nitrogen has been reached.
3. Sized to allow correct purge rate per manufacturer's written instructions and with 14 days.
4. Provide one venting device for each dry/preaction sprinkler system zone.
5. Include a connection port for a portable nitrogen purity sensor or a nitrogen purity manifold.

F. Supervisory Gas Monitoring - Nitrogen Purity Sensing Device:

1. Portable Handheld Nitrogen Purity Sensing Device: Portable sensing device to connect to the outlet of automatic purge/vent valve during periodic inspections to obtain a nitrogen purity reading within each zone.
2. Permanently Mounted Nitrogen Purity Monitoring Device or Manifold: Permanent monitoring device to continuously monitor system's nitrogen purity.

G. BAS Alarm Integration:

1. Provide nitrogen generation system with integrated leak detection and bypass alarms. Program alarms into controller and connect to BAS.

a. Leak detection system is to alarm if leaks develop within fire-suppression system piping.
b. Air bypass alarm is to alarm if nitrogen generation system is bypassed by air compressor.

2.6 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
b. National Fittings, Inc.
c. Shurjoint; a part of Aalberts Integrated piping Systems.
d. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
e. Victaulic Company.

2. Standard: UL 213.
3. Pressure Rating: 350 psig.

4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. AGF Manufacturing, Inc.
   b. Reliable Automatic Sprinkler Co., Inc. (The).
   c. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
   d. Victaulic Company.

2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 350 psig.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. AGF Manufacturing, Inc.
   b. Elkhart Brass Mfg. Co., Inc.
   c. Fire-End & Croker Corporation.
   d. Potter Electric Signal Company, LLC.
   e. Potter Roemer LLC; a Division of Morris Group International.

2. Standard: UL 199.
3. Pressure Rating: 350-psig minimum.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AGF Manufacturing, Inc.
b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
c. Victaulic Company.
d. Viking Group Inc.

2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 350 psig.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aegis Technologies, Inc.
b. CECA, LLC.
c. CPS Products, Inc.
d. Merit Manufacturing.

2. Standard: UL 1474.
3. Pressure Rating: 350 psig.
4. Body Material: Steel pipe with EPDM O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. FlexHead Industries, Inc.
b. Victaulic Company.

2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 350 psig.
5. Size: Same as connected piping, for sprinkler.

2.7 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Globe Fire Sprinkler Corporation.
2. Reliable Automatic Sprinkler Co., Inc. (The).
3. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
4. Victaulic Company.
5. Viking Group Inc.

B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. Pressure Rating for High-Pressure Automatic Sprinklers: 350 psig.

E. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.
2. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

F. Sprinkler Finishes: Chrome plated bronze and painted.

G. Special Coatings: Wax, lead, and corrosion-resistant paint.

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Painted steel, two-piece, with 1-inch vertical adjustment.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

I. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Reliable Automatic Sprinkler Co., Inc. (The).
b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
c. Victaulic Company.
d. Viking Group Inc.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.8 ALARM DEVICES

A. Alarm-device types to match piping and equipment connections.

B. Electrically Operated Alarm Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Fire-Lite Alarms; Honeywell International, Inc.
   b. Notifier; Honeywell International, Inc.
   c. Potter Electric Signal Company, LLC.

2. Strobe/Horn:

   a. Standard: UL 464.
   b. Tone: Selectable, steady, Temporal-3 (T-3) in accordance with ISO 8201 and ANSI/ASA S3.41, 2400 Hz, electromechanical, broadband.
   c. Voltage: 120 V ac, 60 Hz.
   d. Effective Intensity: 110 cd.
   e. Finish: Red, suitable for outdoor use with approved and listed weatherproof backbox. White letters on housing identifying device as for "Fire."
   f. Sign, Integrated: Mount between backbox and strobe/horn with text visible on both sides, above and below strobe/horn. Housing to be shaped to cover surface-mounted weatherproof backbox. Sign is to consists of white lettering on red plastic identifying it as a "Sprinkler Fire Alarm" and instructing viewers to call 911, police, or fire department.

C. Pressure Switches - Water-Flow Alarm Detection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Barksdale, Inc.
   b. Detroit Switch, Inc.
   c. Potter Electric Signal Company, LLC.
   d. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
   e. Viking Group Inc.

2. Standard: UL 346.
3. Type: Electrically supervised, pressure-activated water-flow switch.
4. Components: Two single-pole, double-throw switches.
5. Design Operation: Rising pressure to 6 psi, plus or minus 2 psi signals water flow.
6. Adjustability: Each switch is to be independently adjustable.
7. Wire Separation: Pressure switch to provide separation of wiring to each switch connection to allow for low and high volume connections to comply with NFPA 70 Article 760 requirements.

D. Pressure Switches - Low/High Air Pressure Supervisory:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Barksdale, Inc.
b. Detroit Switch, Inc.
c. Potter Electric Signal Company, LLC.
d. Viking Group Inc.

2. Standard: UL 346.
3. Type: Electrically supervised pressure supervisory switch.
4. Components: Two single-pole, double-throw switches.
5. Design Operation: Detects increase and/or decrease from normal supervisory air pressure.
6. Adjustability: Each switch is to be independently adjustable.
7. Wire Separation: Pressure switch to provide for separation of wiring to each switch connection to allow for low and high voltage connections to comply with NFPA 70 Article 760 requirements.

E. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Fire-Lite Alarms; Honeywell International, Inc.
b. Kennedy Valve Company; a division of McWane, Inc.
c. Potter Electric Signal Company, LLC.
d. System Sensor.

2. General Requirements for Valve Supervisory Switches:

a. Standard: UL 346.
b. Type: Electrically supervised.
c. Design: Signals that controlled valve is in other than fully open position.
d. Wire Terminal Designations: Indicates normal switch position when switch is properly installed on the valve and valve is fully open.

3. Requirements for OS&Y Valve Supervisory Switches:

a. Components: One or two single-pole, double-throw switches.
b. NEMA Rating: NEMA 4 and NEMA 6P enclosures suitable for mounting in any position indoors or outdoors.
c. Visual Switch Indication: Indicates device is properly installed and OS&Y valve is fully open.
d. Mounting Hardware: Mounting bracket to grip valve yoke and prevent movement of switch assembly on OS&Y valve.
e. Trip Rod Length: Adjustable.

4. Requirements for PIV and Butterfly Valve Supervisory Switches:

a. Components: Two single-pole, double-throw switches.
b. NEMA Rating: NEMA 4 and NEMA 6P enclosures suitable for mounting in any position indoors or outdoors.
c. Mounting Hardware: Removable nipple.

d. Trip Rod Length: Adjustable.

5. Requirements for Ball Valve Supervisory Switch:

a. Components: One single-pole, double-throw switch.
b. NEMA Rating: NEMA 4 enclosure suitable for mounting in any position indoors or outdoors.
c. Mounting Hardware: Suitable for mounting directly to pipe, ball valves or backflow preventers sized from up to NPS 2.

2.9 MANUAL CONTROL STATIONS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve.

B. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.10 CONTROL PANELS

A. Description: Single-area, two-area, or single-area cross-zoned-type control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves.

1. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" when used with thermal detectors and Class A detector circuit wiring.
2. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application

B. Manual Control Stations, Electric Operation: Metal enclosure, labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

C. Manual Control Stations, Hydraulic Operation: With union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

D. Panel Components:

1. Power supply.
2. Battery charger.
3. Standby batteries.
4. Field-wiring terminal strip.
5. Electrically supervised solenoid valves and polarized fire-alarm bell.

6. Lamp test facility.
7. Single-pole, double-throw auxiliary alarm contacts.
8. Rectifier.

2.11 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AGF Manufacturing, Inc.
2. AMETEK, Inc.
3. Ashcroft Inc.
4. Brecco Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gauge Range: 0 to 350 psig.

E. Label: Include "WATER" or "AIR/WATER" label on dial face.

F. Air System Piping Gauge: Include retard feature and "AIR" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements in Section 331415 "Site Water Distribution Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-service piping.

C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water service.

3.3 INSTALLATION OF PIPING

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valves to drain piping between fire department connections and check valves. Drain to floor drain or to outside building.

K. Connect compressed-air supply to dry-pipe sprinkler piping.

L. Connect air compressor to the following piping and wiring:

1. Pressure gauges and controls.
2. Electrical power system.
3. Fire-alarm devices, including low-pressure alarm.

M. Install alarm devices in piping systems.

N. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

O. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.

P. Drain dry-pipe sprinkler piping.

Q. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 INSTALLATION OF VALVES AND SPECIALTIES

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install dry-pipe and deluge valves with trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.
    a. Install air-pressure maintenance device with shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig adjustable range; and 350-psig maximum inlet pressure.

3.6 INSTALLATION OF SPRINKLERS

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install sprinklers with water supply from heated space. Do not install pendent or sidewall sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.7 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 NITROGEN-GENERATION, CORROSION-MITIGATION SYSTEM

A. Install in accordance with manufacturer's written installation instructions.

B. Locate purge vent/valve in accordance with manufacturer's written installation instructions.

C. Route alarm signals in code-approved electrical conduit from nitrogen generator system control panel to the supervisory circuit of BAS.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.12 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Standard-Pressure, Dry-Pipe Sprinkler System, NPS 2 and Smaller, to Be One of the Following:

1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

C. Standard-Pressure, Dry-Pipe Sprinkler System, NPS 2-1/2 to NPS 4, to Be One of the Following:

1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.

D. Standard-Pressure, Dry-Pipe Sprinkler System, NPS 5 and NPS 6, to Be One of the Following:

1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.

3.13 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.
5. Deluge-Sprinkler Systems: Upright and pendent, open sprinklers.
6. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted cover plate to match ceiling color.
2. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211316

SECTION 212200 - CLEAN-AGENT FIRE-EXTINGUISHING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Clean-agent fire-extinguishing systems.
2. Pipe and fittings.
3. Valves.
4. Extinguishing-agent containers.
5. Fire-extinguishing clean agent.
6. Discharge nozzles.
7. Manifold and orifice unions.
8. Fire control panels.
9. Detection devices.
10. Manual stations.
11. Switches.
12. Alarm devices.

1.3 DEFINITIONS

A. EPO: Emergency Power Off.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Prepare in accordance with requirements of NFPA 2001, to include, but not be limited to, the following:

1. Include plans, elevations, sections, and attachment details.
2. Include design calculations.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, manufacturer-required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power, signal, and control wiring.

5. Permit-Approved Documents: Working plans and hydraulic calculations approved by authorities having jurisdiction.

C. Delegated-Design Submittal: For clean-agent fire-extinguishing systems indicated to comply with performance and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades. Coordinate for enclosure integrity in accordance with NFPA 2001 requirements.

B. Seismic Qualification Data: Certificates for extinguishing-agent containers and control panels, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For clean-agent fire-extinguishing system to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. FM Global Compliance: Provide components that are FM Approved and that are listed in FM Approvals' "Approval Guide."

C. UL Compliance: Provide equipment listed in UL's "Fire Protection Equipment Directory."

D. Seismic Performance: Fire-suppression piping shall withstand the effects of earthquake motions determined in accordance with NFPA 13 and ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

2.2 CLEAN-AGENT SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ansul; brand of Johnson Controls International plc, Building Solutions North America.
2. Fike Corporation.
3. Kidde; Carrier Global Corporation.
4. Siemens Industry, Inc., Building Technologies Division.

B. Source Limitations: Obtain clean-agent systems from single source from single manufacturer.

C. Description: Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area including the room cavity above the ceiling, below the ceiling, and below the raised floor. System includes separate zones above and below the ceiling and beneath the raised floor. If smoke is detected below the raised floor, extinguishing agent shall be discharged in the underfloor zone only. If smoke is detected below the ceiling, extinguishing agent shall be discharged in zones above and below the ceiling and below the floor. If smoke is detected above the ceiling, extinguishing agent shall be discharged in the zone above the ceiling only.

D. Delegated Design: Design clean-agent fire-extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class C fires as appropriate for areas being protected, and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.

E. Performance Requirements: Discharge FK-5-1-12 within 10 seconds and maintain 6.6 percent concentration by volume at 70 deg F for 10-minute holding time in hazard areas.

1. FK-5-1-12 concentration in hazard areas greater than 10.0 percent immediately after discharge or less than 6.5 percent throughout holding time will not be

accepted without written authorization from Owner and authorities having jurisdiction.

2. System Capabilities: Minimum 620-psig calculated working pressure and 360-psig initial charging pressure.

F. Verified Detection: Devices located in single zone. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating second-detection device.

G. System Operating Sequence:

1. Actuating First Detector: Visual indication on annunciator panel. Energize audible and visual alarms (slow pulse), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire-alarm system.
2. Actuating Second Detector: Visual indication on annunciator panel. Energize audible and visual alarms (fast pulse), shut down power to protected equipment, start time delay for extinguishing-agent discharge for 30 seconds, and discharge extinguishing agent. On agent discharge, release preaction valve to allow water to fill sprinkler system.
3. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.

H. System Operating Sequence: System shall be cross-zoned, air-sampling detectors and photoelectric detectors reporting to a fully programmable microprocessor-based control panel programmed to operate as follows:

1. If one photoelectric detector and air-sampling detector reaches the third detection level (Fire 1), agent discharge will be initiated as described for the third detection level (Fire 1) below.
2. Air-Sampling System:

a. First Detection Level (Alert): Mild audible and visual indication on annunciator panel. Strobe lights flash slowly in the protected area.
b. Second Detection Level (Action): Strong audible and visual indication on annunciator panel. Strobe lights flash rapidly in the protected area.
c. Third Detection Level (Fire 1): Strong audible and visual indication on annunciator panel. Energize horn(s), bell(s), and strobe light(s) in the protected area and outside entry doors. Shut down air-conditioning and ventilating systems serving the protected area, and close doors in the protected area. Send signal to fire-alarm system, initiate 30-second time delay for extinguishing-agent discharge, and discharge extinguishing agent. At agent discharge, terminate power to equipment in the protected area, and release preaction valve to allow water flow to sprinkler system.
d. Fourth Detection Level (Fire 2): Same as Fire 1.

I. Manual stations shall immediately discharge extinguishing agent when activated.

J. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release hand pressure on the switch to cause agent discharge after the time delay has expired.

K. EPO: Will terminate power to protected equipment immediately on actuation.

L. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.

M. Power Transfer Switch: Transfer from normal to standby power source.

2.3 PIPE AND FITTINGS

A. See "FK-5-1-12 Agent Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

C. Steel Pipe: ASTM A53/A53M, Type S, Grade B or ASTM A106/A106M, Grade A; Schedule 40, Schedule 80, and Schedule 160, seamless steel pipe.

1. Threaded Fittings:

    a. Malleable-Iron Fittings: ASME B16.3, Class 300.
    b. Flanges and Flanged Fittings: ASME B16.5, Class 300 unless Class 600 is indicated.
    c. Fittings Working Pressure: 620 psig minimum.
    d. Flanged Joints: Class 300 minimum.

2. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.
3. Steel, Grooved-End Fittings: FM Approved and NRTL listed, ASTM A47/A47M malleable iron or ASTM A536 ductile iron, with dimensions matching steel pipe and ends factory grooved in accordance with AWWA C606.

D. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch-maximum thickness unless thickness or specific material is indicated.

E. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

2.4 VALVES

A. General Valve Requirements:

1. UL listed or FM Approved for use in fire-protection systems.
2. Compatible with type of clean agent used.

B. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.

C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.

D. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

2.5 EXTINGUISHING-AGENT CONTAINERS

A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.

1. Finish: Manufacturer's standard color, enamel or epoxy paint.
2. Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.
3. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

2.6 FIRE-EXTINGUISHING CLEAN AGENT

A. FK-5-1-12 (Novec-1230) Clean Agent: Dodecaflouro-2-methylpentan-3-one.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. 3M.

2. Source Limitations: Obtain clean agents from single source from single manufacturer.

2.7 DISCHARGE NOZZLES

A. Description: Equipment manufacturer's standard one-piece brass or aluminum alloy of type, size, discharge pattern, and capacity required for application.

B. Material: Corrosion-resistant metal.

C. Stamped with orifice size and type.

2.8 FIRE CONTROL PANELS

A. Description: FM Approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240V. ac; with electrical contacts for connection to system components and fire-alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.

1. Mounting: Surface.

D. Supervised Circuits: Separate circuits for each independent hazard area.

1. Detection circuits equal to required number of zones, or addressable devices assigned to required number of zones.
2. Manual pull-station circuit.
3. Alarm circuit.
4. Release circuit.
5. Abort circuit.
6. EPO circuit.

E. Control-Panel Features:

1. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.
2. Automatic switchover to standby power at loss of primary power.
3. Storage container, low-pressure indicator.
4. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.

F. Annunciator Panel: Graphic type showing protected, hazard-area plans, as well as locations of detectors and abort, EPO, and manual stations. Include lamps to indicate device-initiating alarm, electrical contacts for connection to control panel, and stainless steel or aluminum enclosure.

G. Standby Power: Sealed 75Ah lithium batteries with capacity to operate system for 24 hours and alarm for minimum of 15 minutes. Include automatic battery charger that has a varying charging rate between trickle and high depending on battery voltage, and that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, automatic transfer switch, and suitable enclosure.

2.9 DETECTION DEVICES

A. Description: Comply with NFPA 2001, NFPA 72, and UL 268; 24V. dc, nominal.

B. Ionization Detectors: Dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.

C. Photoelectric Detectors: LED light source and silicon photodiode receiving element.

D. Remote Air-Sampling Detector System: Includes air-sampling pipe network, laser-based photoelectric detector, sample transport fan, and control unit.

1. Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of four preset values.
2. Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05 inch wg at all sampling ports.
3. Control Unit: Multizone unit as indicated on Drawings. Provides same system power supply, supervision, and alarm features as specified for the control panel plus separate trouble indication for airflow and detector problems.

E. Signals to the Central Fire-Alarm Control Panel: Any type of local system trouble is reported to central fire-alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to central fire-alarm control panel as separately identified zones.

2.10 MANUAL STATIONS

A. Description: Surface FM Approved or NRTL listed, with clear plastic hinged cover, 120V. ac or low-voltage compatible with controls. Include contacts for connection to control panel.

B. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

C. Abort Switch: "ABORT" caption, momentary contact, with green finish.

D. EPO Switch: "EPO" caption, with yellow finish.

2.11 SWITCHES

A. Description: FM Approved or NRTL listed, where available, 120V. ac or low-voltage compatible with controls. Include contacts for connection to control panel.

1. Low-Agent Pressure Switches: Pneumatic operation.
2. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.

3. Door Closers: Magnetic retaining and release device or electrical interlock to cause door operator to drive the door closed.

2.12 ALARM DEVICES

A. Description: FM Approved or NRTL listed, low voltage, and surface mounting. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" for alarm and monitoring devices.

B. Bells: Minimum 6-inch diameter.

C. Horns: 90 to 94 dBA.

D. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with enclosure integrity requirements, installation tolerances, and other conditions affecting performance of the Work in accordance with NFPA 2001.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FK-5-1-12 AGENT PIPING APPLICATIONS

A. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.

B. NPS 2 and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.

C. NPS 2-1/2 and Larger: Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.

3.3 CLEAN-AGENT SYSTEM INSTALLATION

A. Install clean-agent containers, piping, and other components level and plumb, in accordance with manufacturers' written instructions.

B. Clean-Agent Container Mounting:

1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

C. Grooved Piping Joints: Groove pipe ends in accordance with AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant in accordance with manufacturer's written instructions.

D. Install pipe and fittings, valves, and discharge nozzles in accordance with requirements listed in NFPA 2001, Section "Distribution."

1. Install valves designed to prevent entrapment of liquid, or install pressure relief devices in valved sections of piping systems.
2. Support piping using supports and methods in accordance with NFPA 13.
3. Install seismic restraints for extinguishing-agent piping systems.
4. Install control panels, detection system components, alarms, and accessories, in accordance with requirements listed in NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

3.4 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

E. Connect electrical devices to control panel and to building's fire-alarm system. Electrical power, wiring, and devices are specified in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems."

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 IDENTIFICATION

A. Identify system components and equipment. Comply with requirements for identification specified in Section 210553 "Identification for Fire-Suppression Piping and Equipment."

B. Identify piping, extinguishing-agent containers, other equipment, and panels in accordance with NFPA 2001.

C. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire-extinguishing system.

D. Install signs at entry doors to advise persons outside the room the meaning of horn(s), bell(s), and strobe light(s) outside the protected space.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. After installing clean-agent fire-extinguishing system and after electrical circuitry has been energized, test for compliance in accordance with requirements listed in NFPA 2001, Section "Approval of Installation."
2. Clean-agent fire-extinguishing system and associated protected enclosure will be considered defective if either does not pass required tests and inspections.
3. Prepare test and inspection reports in accordance with requirements listed in NFPA 2001, Section "Installation Acceptance."

3.9 CLEANING

A. Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, using a suitable nonflammable cleaner. Pipe network shall be free of particulate matter and oil residue before installing nozzles or discharge devices.

3.10 OPERATIONAL CONDITION SYSTEM FILLING

A. Preparation:

1. Verify that clean-agent fire-extinguishing system and protected enclosure have passed all required tests and inspections in accordance with NFPA 2001.
2. Verify that clean-agent fire-extinguishing piping system installation is completed and cleaned.
3. Verify complete enclosure integrity.
4. Verify operation of ventilation and exhaust systems.

B. Filling Procedures:

1. Fill clean-agent fire-extinguishing containers with extinguishing agent, and pressurize to indicated charging pressure.
2. Install filled containers.
3. Energize circuits.
4. Adjust operating controls.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain clean-agent fire-extinguishing systems.

END OF SECTION 212200

SECTION 213113 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Horizontally mounted, single-stage, split-case fire pumps.
2. Fire-pump accessories and specialties.
3. Flowmeter systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of fire pump, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire pumps to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 20.

B. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Pump Equipment, Accessory, and Specialty Pressure Rating: 350 psig minimum unless higher pressure rating is indicated.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.3 HORIZONTALLY MOUNTED, SINGLE-STAGE, SPLIT-CASE FIRE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. A-C Fire Pump; a Xylem brand.
2. Peerless Pump Company.
3. Pentair Aurora; Pentair Pump Group.

B. Pump:

1. Standard: UL 448, for split-case pumps for fire service.
2. Casing: Axially split case, cast iron, with ASME B16.1 pipe-flange connections.
3. Impeller: Double suction, cast bronze, statically and dynamically balanced, and keyed to shaft.
4. Wear Rings: Replaceable bronze.
5. Shaft and Sleeve: Alloy steel shaft with bronze sleeve.

    a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
    b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

6. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.

C. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

D. Driver:

1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.

E. Capacities and Characteristics:

1. Rated Capacity: 1000 gpm.
2. Total Rated Head: 245 psig.
3. Inlet Flange: Class 125.
4. Outlet Flange: Class 250.
5. Suction Head Available at Pump: <**Insert feet**>.
6. Motor Horsepower: 350 hp.
7. Motor Speed: 3600 rpm.
8. Electrical Characteristics:

    a. Volts: 460 V.
    b. Phase: Three.
    c. Hertz: 60.

9. Pump-Start, Pressure-Switch Setting: <**Insert psig**>.
10. Pump-Stop, Pressure-Switch Setting: <**Insert psig**>.
11. Rotation [**Clockwise**] [**Counterclockwise**].

2.4 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.

B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.

C. Relief Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. BERMAD Control Valves.
b. CLA-VAL.
c. Kunkle Valve.
d. OCV Control Valves.
e. WATTS; A Watts Water Technologies Company.

2. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

D. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.

E. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.

F. Discharge Cone: [**Closed**] [**Open**] [**Closed or open**] type.

G. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: UL 1726.
5. Manifold:

a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
b. Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe, with ends threaded according to ASME B1.20.1.
d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
e. Escutcheon Plate: Brass or bronze; rectangular.
f. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
g. Exposed Parts Finish: Rough, chrome plated.
h. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

6. Manifold:

    a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
    b. Body: Exposed type, brass, with number of outlets required by NFPA 20.
    c. Escutcheon Plate: Brass or bronze; round.
    d. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
    e. Exposed Parts Finish: Rough, chrome plated.
    f. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.5 FLOWMETER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Fire Research Corp.
2. Gerand Engineering Co.
3. Hose Monster company; a HydroFlow Products, Inc. company.
4. Hyspan Precision Products, Inc.
5. Meriam Process Technologies.
6. Preso Meters; Badger Meter Inc.
7. Reddy-Buffaloes Pump Company.

B. Description: UL-listed or FM-Approved, fire-pump flowmeter system able to indicate flow to not less than 175 percent of fire-pump rated capacity.

C. Pressure Rating: 350 psig.

D. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.

E. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches in diameter. Include bracket or device for wall mounting.

1. Tubing Package: NPS 1/8 or NPS 1/4 soft copper tubing with copper or brass fittings and valves.

F. Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches in diameter and with two 12-foot-long hoses in carrying case.

2.6 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.7 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."

1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment bases and anchorage provisions, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of fire pumps.

B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:

1. Install fire pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."

C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

F. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Section 211313 "Wet-Pipe Sprinkler Systems."

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

J. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.3 ALIGNMENT

A. Align split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connections.

D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

3.4 CONNECTIONS

A. Comply with requirements for piping and valves specified in Section 211313 "Wet-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect relief-valve discharge to drainage piping or point of discharge.

D. Connect flowmeter-system meters, sensors, and valves to tubing.

E. Connect fire pumps to their controllers.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.6 FIELD QUALITY CONTROL

A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 262933 "Controllers for Fire-Pump Drivers."

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 213113

SECTION 213213 - ELECTRIC-DRIVE, VERTICAL-TURBINE FIRE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vertical-turbine fire pumps.
2. Fire-pump accessories and specialties.
3. Flowmeter systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of fire pump, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire pumps to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 20.

B. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Pump Equipment, Accessory, and Specialty Pressure Rating: 350 psig minimum unless higher pressure rating is indicated.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 ASSEMBLY DESCRIPTION

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.3 VERTICAL-TURBINE FIRE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. A-C Fire Pump; a Xylem brand.
2. Peerless Pump Company.
3. S.A. Armstrong Limited.

B. Pump Head: Cast iron, for surface discharge.

1. Discharge Outlet: Flanged with flanges complying with ASME B16.1; except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
2. Pump Head Seal: Stuffing box and packing.
3. Base: Cast iron or steel with hole for electrical cable.

C. Pump:

1. Standard: UL 448, for vertical-turbine pumps for fire service.
2. Discharge Head: High profile, with flange above ground outlet Class 125 for cast iron, and with flange above ground outlet Class 150 for steel, with 0.5-inch NPT pressure gauge connection.
3. Stuffing Box: Cast iron with packing rings, pressure-relief connection, stainless-steel packing gland, bronze bearing, and rubber slinger.
4. Line Shaft: Stainless steel in sections 10 feet or less, with left-hand threaded steel couplings, centering spiders, and fluted rubber bearings.
5. Line Shaft Bearings: Bronze, water lubricated.
6. Bowl Section: Multiple close-grained, flanged cast-iron bowls. Intermediate bowls have enamel- or epoxy- lined waterways for maximum efficiency and wear protection, and they are of identical design for interchangeability. Bowls are fitted with bronze bearings.
7. Impeller: Closed type, stainless steel, dynamically balanced, and securely fastened to the bowl.
8. Suction Bell: Close-grained cast-iron bowl with bronze bearing and bronze sand collar.
9. Wear Rings: Bronze located in the suction and intermediate bowls and with minimum clearance to the surface of the impeller.
10. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded sleeve couplings or rabbet fit flange ends in sections of 10 feet or less.
11. Suction Strainer: Cast or fabricated; bronze, stainless steel, or Monel; and sized to restrict passage of 0.5-inch diameter objects.

D. Driver:

1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.
3. Mounting: On pump head above pump.

E. Capacities and Characteristics:

1. Rated Capacity: 1000 gpm.
2. Total Rated Head: 295 psig.
3. Inlet Column Size: <**Insert NPS**>.
4. Pump Column Length: <**Insert feet**>.

5. Pump Head Outlet Flange: Class 250.
6. Motor Horsepower: 250 hp.
7. Motor Speed: 1800 rpm.
8. Electrical Characteristics:

    a. Volts: 460V.
    b. Phase: Three.
    c. Hertz: 60.
    d. Full-Load Amperes: <**Insert number**> A.
    e. Minimum Circuit Ampacity: <**Insert number**> A.
    f. Maximum Overcurrent Protection: <**Insert number**> A.

9. Pump-Start, Pressure-Switch Setting: <**Insert psig**>.
10. Pump-Stop, Pressure-Switch Setting: <**Insert psig**>.

2.4 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.

B. Relief Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. BERMAD Control Valves.
    b. CLA-VAL.
    c. Kunkle Valve.
    d. OCV Control Valves.
    e. WATTS; A Watts Water Technologies Company.
    f. Zurn Industries, LLC.

2. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

C. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.

D. Discharge Cone: [**Closed**] [**Open**] [**Closed or open**] type.

E. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: UL 1726.
5. Manifold:

a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
b. Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe, with ends threaded according to ASME B1.20.1.
d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
e. Escutcheon Plate: Brass or bronze; rectangular.
f. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
g. Exposed Parts Finish: Rough, chrome plated.
h. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

6. Manifold:

a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
b. Body: Exposed type, brass, with number of outlets required by NFPA 20.
c. Escutcheon Plate: Brass or bronze; round.
d. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
e. Exposed Parts Finish: Rough, chrome plated.
f. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.5 FLOWMETER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Fire Research Corp.
2. Gerand Engineering Co.
3. Hose Monster company; a HydroFlow Products, Inc. company.
4. Hyspan Precision Products, Inc.
5. Meriam Process Technologies.
6. Preso Meters; Badger Meter Inc.
7. Rosemount; Emerson Electric Co., Automation Solutions.
8. Victaulic Company.

B. Description: UL-listed or FM-Approved, fire-pump flowmeter system able to indicate flow to not less than 175 percent of fire-pump rated capacity.

C. Pressure Rating: 350 psig.

D. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.

E. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches in diameter. Include bracket or device for wall mounting.

1. Tubing Package: NPS 1/8 or NPS 1/4 soft copper tubing with copper or brass fittings and valves.

F. Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches in diameter and with two 12-foot-long hoses in carrying case.

2.6 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.7 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."

1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of fire pumps.

B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:

1. Install fire pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."

C. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

F. Install pressure gage on pump-head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Section 211313 "Wet-Pipe Sprinkler Systems."

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

J. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.3 ALIGNMENT

A. Align pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connection.

D. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.

3.4 CONNECTIONS

A. Comply with requirements for piping and valves specified in Section 211313 "Wet-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect relief-valve discharge to drainage piping or point of discharge.

D. Connect flowmeter-system meters, sensors, and valves to tubing.

E. Connect fire pumps to their controllers.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.6 FIELD QUALITY CONTROL

A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 262933 "Controllers for Fire-Pump Drivers."

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 213213

SECTION 213413 - PRESSURE-MAINTENANCE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vertical, multistage, pressure-maintenance pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For pumps, accessories, and specialties.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 VERTICAL, MULTISTAGE, PRESSURE-MAINTENANCE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. A-C Fire Pump; a Xylem brand.
2. Aquarius Fluid Products, Inc.
3. Grundfos Pumps Corporation.

B. Description: Factory-assembled and -tested, multistage, barrel-type vertical pump as defined in HI 2.1-2.2 and HI 2.3; designed for surface installation with pump and motor direct coupled and mounted vertically.

C. Pump Construction:

1. Barrel: Stainless steel.
2. Suction and Discharge Chamber: Cast iron with flanged inlet and outlet.
3. Pump Head/Motor Mount: Cast iron.
4. Impellers: Stainless steel, balanced, and keyed to shaft.
5. Pump Shaft: Stainless steel.
6. Seal: Mechanical type with carbon rotating face and silicon-carbide stationary seat.
7. Wear Rings: Teflon.
8. Intermediate Chamber Bearings: Aluminum-oxide ceramic or bronze.
9. Chamber-Base Bearing: Tungsten carbide.
10. O-Rings: EPDM.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Motor: Single speed with permanently lubricated ball bearings and rigidly mounted to pump head. Comply with requirements in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."

F. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

G. Capacities and Characteristics:

1. Rated Capacity: 10 gpm.
2. Total Dynamic Head: 265 PSI.
3. Working Pressure: 350 psig.
4. Inlet and Outlet Size: NPS 1-1/4.
5. Discharge and Suction Flanges: Class 250.
6. Suction Head Available at Pump: <**Insert feet**>.
7. Motor Horsepower: 7.5.
8. Motor Speed: 3450 rpm.

9. Electrical Characteristics:

    a. Volts: 460.
    b. Phases: Three.
    c. Hertz: 60.
    d. Full-Load Amperes: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection: <**Insert amperage**>.

10. Pump-Start, Pressure-Switch Setting: <**Insert psig**>.
11. Pump-Stop, Pressure-Switch Setting: <**Insert psig**>.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."

1. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.

B. Equipment Mounting:

1. Install multistage, pressure-maintenance pumps according to HI 1.4.
2. Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

    a. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
    b. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."
    c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
    d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

e. Install anchor bolts to elevations required for proper attachment to supported equipment.
f. Attach pumps to equipment base using anchor bolts.
g. Shim pumps as needed to make them level.

3. Install isolation valves in both inlet and outlet pipes near the pump. Comply with requirements for valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 ADJUSTING

A. Lubricate pumps as recommended by manufacturer.

B. Set field-adjustable pressure-switch ranges as indicated.

END OF SECTION 213413

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves without waterstop.
2. Sleeves with waterstop.
3. Stack-sleeve fittings.
4. Sleeve-seal systems.
5. Grout.
6. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES WITHOUT WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.

C. Steel Sheet Sleeves: ASTM A653/A653M, 0.0239-inch minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 SLEEVES WITH WATERSTOP

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, LLC.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).

B. Description: Manufactured steel, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

2.3 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Wade; a subsidiary of McWane Inc.
2. Zurn Industries, LLC.

B. Description: Manufactured, galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.4 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, LLC.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Designed to form a hydrostatic seal of 20 psig minimum.
2. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.5 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000 psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. GE Construction Sealants; Momentive Performance Materials Inc.
b. Permathane; ITW Polymer Sealants North America.
c. Polymeric Systems, Inc.
d. Sherwin-Williams Company (The).
e. Sika Corporation.
f. The Dow Chemical Company.
g. Tremco Incorporated.

2. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES - GENERAL

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 INSTALLATION OF SLEEVES WITH WATERSTOP

A. Install sleeve with waterstop as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout or silicone sealant, seal the space around outside of sleeves.

3.3 INSTALLATION OF STACK-SLEEVE FITTINGS

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.4 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building and passing through exterior walls.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
2. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.6 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above and below Grade:

a. Sleeves with waterstops.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

2. Concrete Slabs-on-Grade:

a. Sleeves with waterstops.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs above Grade:

    a. Sleeves with waterstops or stack-sleeve fittings.

4. Interior Partitions:

    a. Sleeves without waterstops.

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. Mid-America Fittings, Inc.
6. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
c. Insulated Piping: One-piece steel with polished, chrome-plated finish.
d. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
e. Insulated Piping: One-piece cast brass with polished, chrome-plated finish.
f. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
g. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
h. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
i. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.

j. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
k. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
l. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
m. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
n. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
o. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
p. Bare Piping in Unfinished Service Spaces: One-piece cast brass with polished, chrome-plated finish.
q. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
r. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
s. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.
t. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:

a. Chrome-Plated Piping: Split-casting, stamped steel with concealed hinge with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Light-activated thermometers.
5. Thermowells.
6. Pressure gages.
7. Gage attachments.
8. Test plugs.
9. Test-plug kits.
10. Sight flow indicators.

B. Related Requirements:

1. Section 221119 "Domestic Water Piping Specialties" for water meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ashcroft Inc.
2. Trerice, H. O. Co.
3. WATTS; A Watts Water Technologies Company.
4. Weiss Instruments, Inc.
5. Weksler Glass Thermometer Corp.

B. Standard: ASME B40.200.
C. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch nominal diameter.
D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.
E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
H. Window: Plain glass.
I. Ring: Stainless steel.
J. Element: Bimetal coil.
K. Pointer: Dark-colored metal.
L. Accuracy: Plus or minus 1 percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Ashcroft Inc.
    b. Trerice, H. O. Co.
    c. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus 1 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Trerice, H. O. Co.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 6-inch nominal size.
4. Case Form: Back angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.

   a. Design for Thermowell Installation: Bare stem.

9. Connector: 3/4 inch, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.5 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Ashcroft Inc.
    b. Trerice, H. O. Co.
    c. WATTS; A Watts Water Technologies Company.
    d. Weiss Instruments, Inc.
    e. Weksler Glass Thermometer Corp.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trerice, H. O. Co.
2. WATTS; A Watts Water Technologies Company.
3. Weiss Instruments, Inc.
4. Weksler Glass Thermometer Corp.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.8 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. IMI Flow Design, Inc.
2. Trerice, H. O. Co.
3. WATTS; A Watts Water Technologies Company.
4. Weiss Instruments, Inc.

B. Furnish one test-plug kit containing one thermometer, one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install valve and snubber in piping for each pressure gage for fluids.

H. Install test plugs in piping tees.

I. Install thermometers in the following locations:

1. Inlet and outlet of each domestic water heater.

J. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Metal case, compact-style, liquid-in-glass type.
4. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

B. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping:

1. 0 to 100 deg F.

B. Scale Range for Domestic Hot-Water Piping:

1. 0 to 250 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be one of the following:

1. Sealed, direct-mounted, metal case.
2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be one of the following:

1. Sealed, direct-mounted, metal case.
2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

C. Pressure gages at suction and discharge of each domestic water pump shall be one of the following:

1. Sealed, direct-mounted, metal case.
2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping:

1. 0 to 100 psi.

B. Scale Range for Domestic Water Piping:

1. 0 to 100 psi.
2. 0 to 160 psi.

END OF SECTION 220519

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Bronze ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

   1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, and soldered ends.
   3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for solder-joint connections.
6. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
2. Hand lever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; Conbraco Industries, Inc.
b. Crane; Crane Energy Flow Solutions.
c. Hammond Valve.
d. Lance Valves.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts; a Watts Water Technologies company.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded or soldered.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze ball valves, two-piece with full port and stainless-steel trim.

END OF SECTION 220523.12

SECTION 220523.13 - BUTTERFLY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.
2. Iron, grooved-end butterfly valves.
3. Chainwheels.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set butterfly valves closed or slightly open.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B16.5 for flanges on steel valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.9 for building service piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Hand lever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, hand lever, or stem; of size and with chain for mounting height, according to "Valve Installation" Article.

H. Valves in Insulated Piping: With 2-inch stem extensions.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International.
b. Kennedy Valve Company: a division of McWane, Inc.
c. Mueller Steam Specialty.
d. NIBCO Inc.
e. Shurjoint Piping Products.
f. Tyco Fire Products LP.
g. Victaulic

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating, NPS 12 and Smaller: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Stainless steel.

2.3 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. Ductile Iron, Grooved-End Butterfly Valves, 300 CWP:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International.
b. Kennedy Valve Company; a division of McWane, Inc.
c. Mueller Steam Specialty.
d. NIBCO INC.
e. Shurjoint Piping Products USA Inc.
f. Tyco Fire Products LP.
g. Victaulic Company.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating, NPS 8 and Smaller: 300 psig.
c. CWP Rating, NPS 10 and Larger: 200 psig.
d. Body Material: Coated, ductile iron.
e. Stem: Two-piece stainless steel.
f. Disc: Coated, ductile iron.
g. Seal: EPDM.

2.4 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG OR LESS)

A. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, stainless-steel disc.

B. Ductile-Iron, Grooved-End Butterfly Valves: 300 CWP.

3.5 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG

A. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, stainless-steel disc.

B. Ductile-Iron, Grooved-End Butterfly Valves: 300 CWP.

3.6 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, stainless-steel disc.

B. Ductile-Iron, Grooved-End Butterfly Valves: 300 CWP.

END OF SECTION 220523.13

SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze, lift check valves.
2. Bronze, swing check valves.
3. Bronze, swing check valves, press ends.
4. Iron, swing check valves.
5. Iron, swing check valves with closure control.
6. Iron, groove-end swing check valves.
7. Iron, center-guided check valves.
8. Iron, plate-type check valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer.

C. NBR: Nitrile butadiene rubber (also known as Buna-N).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, press connections, and weld ends.
3. Set check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Standards:

1. Domestic water piping check valves intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372, or to be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges for metric standard piping.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast-copper solder joint.
6. ASME B16.22 for wrought copper solder joint.
7. ASME B16.51 for press joint.
8. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for groove-end connections.

D. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BRONZE, LIFT CHECK VALVES

A. Bronze, Lift Check Valves with Bronze Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Metraflex Company (The).
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Stockham; a Crane Co. brand.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

B. Bronze, Lift Check Valves with Nonmetallic Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Milwaukee Valve Company.
b. NIBCO INC.
c. Red-White Valve Corp.
d. Stockham; a Crane Co. brand.
e. Victaulic Company.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: NBR, PTFE.

2.4 BRONZE SWING CHECK VALVES

A. Bronze, Swing Check Valves with Bronze Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. Red-White Valve Corp.
e. Stockham; a Crane Co. brand.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

B. Bronze, Swing Check Valves with Nonmetallic Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. Red-White Valve Corp.
e. Stockham; a Crane Co. brand.

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: PTFE.

C. Bronze, Swing Check Valves with Bronze Disc, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Red-White Valve Corp.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig.

c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

D. Bronze, Swing Check Valves with Nonmetallic Disc, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Milwaukee Valve Company.
b. NIBCO INC.
c. Red-White Valve Corp.
d. Stockham; a Crane Co. brand.

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: PTFE.

E. Bronze, Swing Check Valves, Press Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. NIBCO INC.

2. Description:

a. Standard: MSS SP-80 and MSS SP-139.
b. CWP Rating: Minimum 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B584, bronze.
e. Ends: Press.
f. Press Ends Connection Rating: Minimum 200 psig
g. Disc: Brass or bronze.

2.5 IRON, SWING CHECK VALVES

A. Iron, Swing Check Valves with Metal Seats, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
    b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    c. Clow Valve Company; a subsidiary of McWane, Inc.
    d. Hammond Valve.

2. Description:

    a. Standard: MSS SP-71, Type I.
    b. CWP Rating: 200 psig.
    c. Body Design: Clear or full waterway.
    d. Body Material: ASTM A126, gray iron with bolted bonnet.
    e. Ends: Flange or threaded. See valve schedule articles.
    f. Trim: Bronze.
    g. Gasket: Asbestos free.

B. Iron, Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Bray International, Inc.
    b. Kennedy Valve Company; a division of McWane, Inc.
    c. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
    d. Victaulic Company.

2. Description:

    a. Standard: MSS SP-71, Type I.
    b. CWP Rating: 200 psig.
    c. Body Design: Clear or full waterway.
    d. Body Material: ASTM A126, gray iron with bolted bonnet.
    e. Ends: Flange or threaded. See valve schedule articles.
    f. Trim: Composition.
    g. Seat Ring: Bronze.
    h. Disc Holder: Bronze.
    i. Disc: PTFE.
    j. Gasket: Asbestos free.

C. Iron, Swing Check Valves with Metal Seats, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    b. Bray International, Inc.
    c. Hammond Valve.

2. Description:

a. Standard: MSS SP-71, Type I.
b. CWP Rating: 500 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flange or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.

2.6 IRON, SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron, Swing Check Valves with Lever- and Spring-Closure Control, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Bray International, Inc.
c. Clow Valve Company; a subsidiary of McWane, Inc.
d. Kennedy Valve Company; a division of McWane, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flange or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed exterior lever and weight.

B. Iron, Swing Check Valves with Lever and Weight-Closure Control, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Bray International, Inc.
c. Clow Valve Company; a subsidiary of McWane, Inc.
d. Kennedy Valve Company; a division of McWane, Inc.
e. Milwaukee Valve Company.

2. Description:

a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.

d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flange or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed exterior lever and weight.

2.7 IRON, GROOVE-END SWING CHECK VALVES

A. Iron, Groove-End Swing Check Valves, 300 CWP:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
c. Victaulic Company.

2. Description:

a. CWP Rating: 300 psig.
b. Body Material: ASTM A536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring operated, ductile iron or stainless steel.

2.8 IRON, CENTER-GUIDED, SPRING-LOADED CHECK VALVES

A. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
c. Milwaukee Valve Company.

2. Description:

a. Standard: MSS SP-125.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A126, gray iron.
d. Style: Compact wafer, spring loaded.
e. Seat: Bronze.

B. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Milwaukee Valve Company.
b. Val-Matic Valve & Manufacturing Corp.
c. Watts Water Technologies; a Watts company.

2. Description:

a. Standard: MSS SP-125.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A126, gray iron.
d. Style: Globe, spring loaded.
e. Ends: Flange.
f. Seat: Bronze.

C. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
c. Metraflex Company (The).
d. Victaulic Company.

2. Description:

a. Standard: MSS SP-125.
b. CWP Rating: 300 psig.
c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
d. Style: Compact wafer, spring loaded.
e. Seat: Bronze.

D. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Metraflex Company (The).

2. Description:

a. Standard: MSS SP-125.
b. CWP Rating: 300 psig.
c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
d. Style: Globe, spring loaded.
e. Ends: Flange.
f. Seat: Bronze.

E. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
    b. Metraflex Company (The).
    c. Victaulic Company.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 400 psig.
    c. Body Material: ASTM A126, gray iron.
    d. Style: Compact wafer, spring loaded.
    e. Seat: Bronze.

F. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Metraflex Company (The).
    b. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 400 psig.
    c. Body Material: ASTM A126, gray iron.
    d. Style: Globe, spring loaded.
    e. Ends: Flange.
    f. Seat: Bronze.

G. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
    b. Metraflex Company (The).
    c. Victaulic Company.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 500 psig.
    c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
    d. Style: Compact wafer, spring loaded.
    e. Seat: Bronze.

H. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Metraflex Company (The).

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 500 psig.
    c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
    d. Style: Globe, spring loaded.
    e. Ends: Flange.
    f. Seat: Bronze.

I. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    b. Val-Matic Valve & Manufacturing Corp.
    c. Victaulic Company.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM A126, gray iron.
    d. Style: Compact wafer, spring loaded.
    e. Seat: EPDM.

J. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM A126, gray iron.
    d. Style: Globe, spring loaded.
    e. Ends: Flange.
    f. Seat: EPDM.

K. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Flomatic Valves; Flomatic Corporation.
    b. Val-Matic Valve & Manufacturing Corp.
    c. Victaulic Company.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 300 psig.
    c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
    d. Style: Compact wafer, spring loaded.
    e. Seat: EPDM.

L. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Flomatic Valves; Flomatic Corporation.
    b. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 300 psig.
    c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
    d. Style: Globe, spring loaded.
    e. Ends: Flange.
    f. Seat: EPDM.

M. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Flomatic Valves; Flomatic Corporation.
    b. Val-Matic Valve & Manufacturing Corp.
    c. Victaulic Company.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 400 psig.
    c. Body Material: ASTM A126, gray iron.
    d. Style: Compact wafer, spring loaded.
    e. Seat: EPDM.

N. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Flomatic Valves; Flomatic Corporation.
    b. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 400 psig.
    c. Body Material: ASTM A126, gray iron.
    d. Style: Globe, spring loaded.
    e. Ends: Flange.
    f. Seat: EPDM.

O. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Flomatic Valves; Flomatic Corporation.
    b. Victaulic Company.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 500 psig.
    c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
    d. Style: Compact wafer, spring loaded.
    e. Seat: EPDM.

P. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Flomatic Valves; Flomatic Corporation.
    b. Shurjoint; a part of Aalberts Integrated piping Systems.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 500 psig.
    c. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
    d. Style: Globe, spring loaded.
    e. Ends: Flange.
    f. Seat: EPDM.

2.9 IRON, PLATE-TYPE CHECK VALVES

A. Iron, Dual-Plate Check Valves with Metal Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
   b. Bray International, Inc.
   c. Flomatic Valves; Flomatic Corporation.
   d. Metraflex Company (The).
   e. Shurjoint; a part of Aalberts Integrated piping Systems.

2. Standard: API 594.
3. CWP Rating: 200 psig.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A126, gray iron.
6. Seat: Bronze.

B. Iron, Dual-Plate Check Valves with Metal Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
   b. Bray International, Inc.
   c. Legend Valve & Fitting, Inc.
   d. Metraflex Company (The).
   e. Stockham; a Crane Co. brand.
   f. Sure Flow Equipment Inc.

2. Standard: API 594.
3. CWP Rating: 300 psig.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
6. Seat: Bronze.

C. Iron, Dual-Plate Check Valves with Metal Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
   b. Bray International, Inc.
   c. Stockham; a Crane Co. brand.
   d. Val-Matic Valve & Manufacturing Corp.

2. Standard: API 594.
3. CWP Rating: 400 psig.
4. Body Design: Wafer, spring-loaded plates.

5. Body Material: ASTM A126, gray iron.
6. Seat: Bronze.

D. Iron, Dual-Plate Check Valves with Metal Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
   b. Bray International, Inc.
   c. Shurjoint; a part of Aalberts Integrated piping Systems.

2. Standard: API 594.
3. CWP Rating: 500 psig.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
6. Seat: Bronze.

E. Iron, Single-Plate Check Valves with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Flowserve Corporation.
   b. GA Industries, Inc.
   c. Jomar Valve.
   d. Keckley Company.

2. Standard: API 594.
3. CWP Rating: 200 psig.
4. Body Design: Wafer, spring-loaded plate.
5. Body Material: ASTM A126, gray iron.
6. Seat: EPDM.

F. Iron, Dual-Plate Check Valves with Resilient Seat, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bray International, Inc.
   b. Flomatic Valves; Flomatic Corporation.
   c. Stockham; a Crane Co. brand.

2. Standard: API 594.
3. CWP Rating: 200 psig.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A126, gray iron.
6. Seat: EPDM.

G. Iron, Dual-Plate Check Valves with Resilient Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Bray International, Inc.
    b. Stockham; a Crane Co. brand.

2. Standard: API 594.
3. CWP Rating: 300 psig.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
6. Seat: EPDM.

H. Iron, Wafer, Single-Plate Check Valves with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Victaulic Company.

2. Standard: API 594.
3. CWP Rating: 400 psig.
4. Body Design: Wafer, spring-loaded plate.
5. Body Material: ASTM A126, gray iron.
6. Seat: EPDM.

I. Iron, Dual-Plate Check Valves with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Stockham; a Crane Co. brand.
    b. Val-Matic Valve & Manufacturing Corp.

2. Standard: API 594.
3. CWP Rating: 400 psig.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A126, gray iron.
6. Seat: EPDM.

J. Iron, Dual-Plate Check Valves with Resilient Seat, Class 300:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Shurjoint; a part of Aalberts Integrated piping Systems.
    b. Sure Flow Equipment Inc.

2. Standard: API 594.
3. CWP Rating: 500 psig.
4. Body Design: Wafer, spring-loaded plates.

5. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
6. Seat: EPDM.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Examine press fittings to verify they have been properly pressed.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that stems are horizontal or slope upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.

H. Check Valves: Install check valves for proper direction of flow.

1. Swing Check Valves: In horizontal position with hinge pin level.

2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

I. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

J. Adhere to manufacturer's installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:

a. NPS 2 and Smaller: Bronze, swing check valves with bronze or nonmetallic disc.
b. NPS 2-1/2 and Larger for Domestic Water: Iron, swing check valves with lever and weight or spring; or iron, center-guided, metal-seat or resilient-seat check valves.
c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron, swing check valves with lever and weight or spring.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded, soldered, or press-end connections.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flange or threaded.
3. For Copper Tubing, NPS 5 and Larger: Flange.
4. For Steel Piping, NPS 2 and Smaller: Threaded.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flange or threaded.
6. For Steel Piping, NPS 5 and Larger: Flange.
7. For Groove-End Copper Tubing and Steel Piping: Groove.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze, swing check valves with bronze disc, Class 150, with soldered end connections.
2. Bronze, swing check valves with press-end connections.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, swing check valves with nonmetallic-to-metal seats, Class 250, with threaded or flanged end connections.
2. Iron, swing check valves with closure control lever and spring, Class 125, with threaded or flanged end connections.
3. Iron, groove-end swing check valves, 300 CWP.
4. Iron, center-guided check valves with compact wafer, Class 150.
5. Iron, center-guided check valves with globe, resilient seat, Class 150, with threaded or flanged end connections.
6. Iron, dual-plate check valves with resilient seat, Class 150, with threaded or flanged end connections.
7. Iron, single-plate check valves with resilient seat, Class 250, with threaded or flanged end connections.

END OF SECTION 220523.14

SECTION 220523.15 - GATE VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.
3. Chainwheels.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer.

C. NRS: Nonrising stem.

D. OS&Y: Outside screw and yoke.

E. RS: Rising stem.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, press connections, and weld ends.
3. Set gate valves closed to prevent rattling.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels, stems, or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Standards:

1. Domestic water piping check valves intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372, or to be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on metric standard piping.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast-copper solder joint.
6. ASME B16.22 for wrought copper solder joint.
7. ASME B16.51 for press joint.
8. ASME B31.9 for building services piping valves.

C. AWWA Compliance: AWWA C606 for groove-end connections.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valves in Insulated Piping: With 2-inch stem extensions.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BRONZE GATE VALVES

A. Bronze Gate Valves, NRS, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Valve, Inc.
b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
c. Milwaukee Valve Company.
d. Red-White Valve Corp.
e. Stockham; a Crane Co. brand.
f. Watts Water Technologies; a Watts company.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: Bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

B. Bronze Gate Valves, RS, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Stockham; a Crane Co. brand.
f. Watts Water Technologies; a Watts company.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: Bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

C. Bronze Gate Valves, NRS, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. American Valve, Inc.
    b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    c. Milwaukee Valve Company.
    d. Red-White Valve Corp.
    e. Stockham; a Crane Co. brand.
    f. Watts Water Technologies; a Watts company.

2. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 300 psig.
    c. Body Material: Bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem: Bronze.
    f. Disc: Solid wedge; bronze.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron, bronze, or aluminum.

D. Bronze Gate Valves, RS, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    b. Hammond Valve.
    c. Milwaukee Valve Company.
    d. Stockham; a Crane Co. brand.
    e. Watts Water Technologies; a Watts company.

2. Description:

    a. Standard: MSS SP-80, Type 2.
    b. CWP Rating: 300 psig.
    c. Body Material: Bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem: Bronze.
    f. Disc: Solid wedge; bronze.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron, bronze, or aluminum.

E. Bronze Gate Valves, Press Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    b. Hammond Valve.

c. Milwaukee Valve Company.
d. NIBCO INC.

2. Description:

a. Standard: MSS SP-80 and MSS SP-139.
b. CWP Rating: Minimum 200 psig.
c. Body Material: Bronze with integral seat and union-ring bonnet.
d. Ends: Press.
e. Press Ends Connection Rating: Minimum 200 psig.
f. Stem: Brass or bronze, rising.
g. Disc: Solid wedge; bronze.
h. Packing: Graphite.
i. Port: Full.
j. Handwheel: Malleable iron, bronze, or aluminum.

2.4 IRON GATE VALVES

A. Iron Gate Valves, NRS, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Clow Valve Company; a subsidiary of McWane, Inc.
c. Cooper Valves.
d. Kennedy Valve Company; a division of McWane, Inc.
e. Powell Valves.

2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig.
c. Body Material: Gray iron with bolted bonnet.
d. Ends: Flange.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

B. Iron Gate Valves, OS&Y, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.

e. Watts Water Technologies; a Watts company.

2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig.
c. Body Material: Gray iron with bolted bonnet.
d. Ends: Flange.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

C. Iron Gate Valves, NRS, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Clow Valve Company; a subsidiary of McWane, Inc.
c. Crane Fluid Systems; Crane Co.
d. Victaulic Company.
e. Zurn Industries, LLC.

2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 500 psig.
c. Body Material: Gray iron with bolted bonnet.
d. Ends: Flange.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

D. Iron Gate Valves, OS&Y, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Crane Fluid Systems; Crane Co.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America.
f. Victaulic Company.
g. Watts Water Technologies; a Watts company.
h. Zurn Industries, LLC.

2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 500 psig.
c. Body Material: Gray iron with bolted bonnet.
d. Ends: Flange.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

2.5 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries; Rotork.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.

1. Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Examine press joint surfaces. Verify they are clean and free from dents and burrs, and that o-ring seals are in place and undamaged.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that stems are horizontal or slope upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.

H. Install chainwheels on manual operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

I. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

J. Adhere to manufacturer's installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Use gate valves for shutoff service only.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded, soldered, or press-end connections.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flange or threaded.

3. For Copper Tubing, NPS 5 and Larger: Flange.
4. For Steel Piping, NPS 2 and Smaller: Threaded.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flange or threaded.
6. For Steel Piping, NPS 5 and Larger: Flange.
7. For Groove-End Copper Tubing and Steel Piping: Groove.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze gate valves, RS, Class 125 with threaded ends.
2. Bronze gate valves, press ends.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y, Class 125 with flange ends.

END OF SECTION 220523.15

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal hanger-shield inserts.
4. Fastener systems.
5. Pipe stands.
6. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" and Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 ACTION SUBMITTALS

A. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

B. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL HANGER-SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with 100-psig or ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: stainless steel.
2. Outdoor Applications: Stainless steel.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand:

1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

C. Low-Profile, Single-Base, Single-Pipe Stand:

1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Vertical Members: Two stainless-steel, continuous-thread, 1/2-inch rods.
4. Horizontal Member: Adjustable horizontal, stainless-steel pipe support channels.
5. Pipe Supports: Roller.
6. Hardware: Stainless steel.
7. Accessories: Protection pads.
8. Height: 12 inches above roof.

D. High-Profile, Single-Base, Single-Pipe Stand:

1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Single vulcanized rubber or molded polypropylene.
3. Vertical Members: Two stainless-steel, continuous-thread, 1/2-inch rods.
4. Horizontal Member: One adjustable-height, stainless-steel, pipe-support slotted channel or plate.
5. Pipe Supports: Roller.
6. Hardware: Stainless steel.
7. Accessories: Protection pads, 1/2-inch, continuous-thread, stainless-steel rod.
8. Height: 36 inches above roof.

E. High-Profile, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; vulcanized rubber or molded polypropylene.
3. Vertical Members: Two or more, stainless-steel channels.

4. Horizontal Members: One or more, adjustable-height, stainless-steel pipe support.
5. Pipe Supports: Roller.
6. Hardware: Stainless steel.
7. Accessories: Protection pads, 1/2-inch, continuous-thread rod.
8. Height: 36 inches above roof.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

2.8 MATERIALS

A. Aluminum: ASTM B 221.

B. Carbon Steel: ASTM A 1011/A 1011M.

C. Structural Steel: ASTM A 36/A 36M carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A 240/A 240M.

E. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe Stand Installation:

1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099123 "Interior Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal hanger-shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction occurs.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

S. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220533 - HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes heat tracing of plumbing piping for freeze prevention with self-regulating, parallel-resistance electric heating cables:

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables and controls to include in operation and maintenance manuals.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. RAYCHEM; brand of nVent Electrical plc.
2. Thermon Americas Inc.

B. Source Limitations: Obtain all heat tracing from one manufacturer.

C. Standard: IEEE 515.1.

D. Heating Element: Pair of parallel No. 16 AWG, nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length.

E. Electrical Insulating Jacket: Flame-retardant polyolefin.

F. Grounding Cover: Tinned-copper braid.

G. Cable Cover: Polyolefin outer jacket with ultraviolet inhibitor.

H. Terminate cable with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable is to be capable of crossing over itself once without overheating.

I. Maximum Operating Temperature (Power On): 150 deg F.

J. Maximum Exposure Temperature (Power Off): 185 deg F.

K. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a qualified testing agency and marked for intended location and application.

L. Capacities and Characteristics:

1. Minimum Heat Output: 3 W/ft..
   a. Heat Trace cable type and sizing to be based on pipe diameter, fluid material and freeze protection requirements.
2. Electrical Characteristics for Single-Circuit Connection:

   a. Volts: 120 V.
   b. Phase: 1.
   c. Full-Load Amperes: 20 A.

2.2 CONTROLS

A. Thermostats for Freeze Protection:

1. Remote bulb temperature control unit with adjustable range from 30 to 50 deg F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote temperature-sensing bulb on capillary, resistance temperature device, or thermistor for directly sensing outside air or pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

B. Control Panel:

1. Automatic control with manual on, automatic, and standby/reset switch.
2. Remote temperature sensor senses outside air temperature; programmable to energize the freeze-protection cable when temperature falls below 34 to 44 deg F.
3. Remote temperature sensor senses domestic hot water temperature: programmable to control the domestic hot water temperature at 110 to 120 deg F.
4. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and temperature sensors.
5. Minimum 30 A contactor to energize cable or close other contactors.
6. Ground-fault protection.
7. Single-point control of heat tracing for freeze protection.
8. Provide communication ports with contacts, RS485, or Ethernet interface for remote monitoring and alarm by central HVAC-control system. Coordinate type of connection ports with Section 230923 "Direct Digital Control (DDC) System for HVAC."

C. Programmable Timer for Domestic Hot-Water-Temperature Maintenance:

1. Microprocessor based.
2. Minimum of four separate schedules.
3. Minimum 24-hour battery carryover.
4. On-off-auto switch.
5. 365-day calendar with 20 programmable holidays.
6. Relays with contacts to indicate operational status, on or off, and for interface with BMS-control system.

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: See Section 220553 "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install electric heating cable at locations indicated and in accordance with NFPA 70.

B. Install electric heating cable across expansion, construction, and control joints in accordance with manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.

C. Install electric heating cables after piping has been tested and before insulation is installed.

D. Install electric heating cables in accordance with IEEE 515.1.

E. Install insulation over piping with electric cables in accordance with Section 220719 "Plumbing Piping Insulation."

F. Install warning tape on piping insulation where piping is equipped with electric heating cables.

G. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install temperature-control units in an accessible location and in accordance with manufacturer's written instructions. Locate sensing bulbs to sense outside air temperature in a location where it will not be affected by direct sunlight or other heat sources.

I. Install control panels and distribution panels where indicated and in accordance with manufacturer's written instructions.

J. Install and connect outside air and pipe temperature sensors.

3.3 ELECTRICAL CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Connect temperature-control unit for freeze protection to interrupt power supply to electric heating cable when outside air is above set point.

D. Connect temperature-control unit for domestic hot-water-temperature maintenance to interrupt power supply to electric heating cable when hot water is above set point.

E. Connect remote electronic temperature sensors.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings, such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

D. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

E. Cables will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION 220533

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Pipe-riser resilient supports.
5. Resilient pipe guides.
6. Elastomeric hangers.
7. Snubbers.
8. Restraint channel bracings.
9. Seismic-restraint accessories.
10. Mechanical anchor bolts.

B. Related Requirements:

1. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: C.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.

a. Component Importance Factor: 1.5.
b. Component Response Modification Factor: 2.5.
c. Component Amplification Factor: 1.0.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 12.64%g.
4. Design Spectral Response Acceleration at 1.0-Second Period: 9.63%g.
5. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES.

a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.
b. Isolation Technology, Inc.
c. Kinetics Noise Control, Inc.
d. Mason Industries, Inc.
e. Vibration Eliminator Co., Inc.
f. Vibration Isolation.
g. Vibration Management Corp.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Smooth pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.

a. Surface Pattern: Smooth pattern.
b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.

b. Isolation Technology, Inc.
c. Mason Industries, Inc.
d. NOVIA; a division of Carpenter & Paterson.
e. Vibration Eliminator Co., Inc.
f. Vibration Isolation.
g. Vibration Management Corp.

2. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.
b. Isolation Technology, Inc.
c. Mason Industries, Inc.
d. NOVIA; a division of Carpenter & Paterson.
e. Vibration Eliminator Co., Inc.
f. Vibration Isolation.
g. Vibration Management Corp.

2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.

2. Maximum Load Per Support: 500 psigon isolation material providing equal isolation in all directions.

2.6 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.7 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.
b. Kinetics Noise Control, Inc.
c. Mason Industries, Inc.
d. NOVIA; a division of Carpenter & Paterson.
e. Vibration Eliminator Co., Inc.
f. Vibration Isolation.
g. Vibration Management Corp.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.8 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. VMC GROUP.
4. Vibration Management Corp.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.9 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.10 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.11 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-line; brand of Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Powers Fasteners.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different

structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 220548

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Champion America.
d. Craftmark Pipe Markers.
e. Marking Services, Inc.
f. Seton Identification Products.

2. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Champion America.
d. Craftmark Pipe Markers.
e. Seton Identification Products.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Champion America.
4. Craftmark Pipe Markers.
5. Marking Sevices Inc.
6. Stranco, Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick and having predrilled holes for attachment hardware.

C. Letter Color: Red.

D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.

2. Brimar Industries, Inc.
3. Champion America.
4. Craftmark Pipe Markers.
5. Marking Sevices Inc.
6. Seton Identification Products.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Champion America.
4. Craftmark Pipe Markers.
5. Marking Sevices Inc.
6. Seton Identification Products.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain or S-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Champion America.
4. Craftmark Pipe Markers.
5. Marking Sevices Inc.
6. Seton Identification Products.

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:

1. Low-Pressure Compressed Air Piping:

   a. Background: Safety blue.
   b. Letter Colors: White.

2. High-Pressure Compressed Air Piping:

   a. Background: Safety blue.
   b. Letter Colors: White.

3. Domestic Water Piping

   a. Background: Safety green.
   b. Letter Colors: White.

4. Sanitary Waste and Storm Drainage Piping:

   a. Background Color: Safety white.
   b. Letter Color: Black.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Cold Water: 1-1/2 inches, round.
b. Hot Water: 1-1/2 inches, round.
c. Low-Pressure Compressed Air: 1-1/2 inches, round.
d. High-Pressure Compressed Air: 1-1/2 inches, round.

2. Valve-Tag Colors:

a. Cold Water: Natural.
b. Hot Water: Natural.
c. Low-Pressure Compressed Air: Natural.
d. High-Pressure Compressed Air: Natural.

3. Letter Colors:

a. Cold Water: White.
b. Hot Water: White.
c. Low-Pressure Compressed Air: White.
d. High-Pressure Compressed Air: White.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 220553

SECTION 220716 - PLUMBING EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following plumbing equipment:

1. Domestic water, hot-water and cold-water pumps.
2. Domestic water softener tanks.
3. Brine Pumps.

B. Related Sections:

1. Section 220719 "Plumbing Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail removable insulation at equipment connections and access panels.
4. Detail application of field-applied jackets.
5. Detail application at linkages of control devices.
6. Detail field application for each equipment type.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches square.
2. Sheet Jacket Materials: 12 inches square.

3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Equipment Mockups: One tank or vessel, pump,.
2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Block Insulation: ASTM C 552, Type I.
2. Special-Shaped Insulation: ASTM C 552, Type III.
3. Board Insulation: ASTM C 552, Type IV.
4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

K. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

L. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

M. Mineral-Fiber, Preformed Pipe Insulation:
1. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

N. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

O. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

F. Grade A for bonding insulation jacket lap seams and joints.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
2. Service Temperature Range: 0 to 180 deg F.
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.6 SEALANTS

A. Joint Sealants for Cellular-Glass Products:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

5. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

6. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
2. Color: Color-code jackets based on system. Color as selected by Architect.
3. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.
2. Film Thickness: 4 mils.
3. Adhesive Thickness: 1.5 mils.

4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

    a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

    a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
    b. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

    a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    c. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

    a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1-inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from

each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from galvanized steel, at least 0.050 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Domestic Water Boiler Breechings:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap

edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap

seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.8 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Domestic water pump insulation shall be one of the following:

1. Cellular Glass: 2 inches thick.
2. Mineral-Fiber Blanket: 1 inch thick and 3-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.

D. Domestic water softener tanks and pressure/expansion tank insulation shall be one of the following:

1. Cellular Glass: 2 inches thick.
2. Flexible Elastomeric: 1 inch thick.
3. Mineral-Fiber Pipe and Tank: 1 inch thick.
4. Polyolefin: 1 inch thick.

E. Brine pump casings shall be one of the following:

1. Cellular Glass: 3 inches thick.
2. Flexible Elastomeric: 2 inch thick.
3. Mineral-Fiber Pipe and Tank: 2 inch thick.
4. Polyolefin: 2 inch thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed or Exposed:
1. PVC, Color-Coded by System: 30 mils thick.
2. Aluminum, Stucco Embossed: 0.024 inch thick.
3. Painted Aluminum, Stucco Embossed: 0.024 inch thick.
4. Stainless Steel, Type 304 or Type 316, Stucco Embossed: 0.020 inch thick.

3.12 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed or Exposed:
   1. Aluminum, Stucco Embossed: 0.032 inch thick.
   2. Painted Aluminum, Stucco Embossed: 0.032 inch thick.
   3. Stainless Steel, Type 316, Stucco Embossed: 0.024 inch thick.

END OF SECTION 220716

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Roof drains and rainwater leaders.
5. Supplies and drains for handicap-accessible lavatories and sinks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of the manufacturer, fabricator, type, description, and size, as well as ASTM standard designation and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534/C534M, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Aeroflex USA.
    b. Armacell LLC.
    c. K-Flex USA.

F. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Johns Manville; a Berkshire Hathaway company.
    b. Knauf Insulation.
    c. Manson Insulation Inc.
    d. Owens Corning.

2. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ.
3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 INSULATING CEMENTS

A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ramco Insulation, Inc.

B. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ramco Insulation, Inc.

2.4 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA.
b. Armacell LLC.
c. Foster Brand; H. B. Fuller Construction Products.
d. K-Flex USA.

2. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
3. Wet Flash Point: Below 0 deg F.
4. Service Temperature Range: 40 to 200 deg F.
5. Color: Black.

C. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Mon-Eco Industries, Inc.

D. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Johns Manville; a Berkshire Hathaway company.
    b. P.I.C. Plastics, Inc.
    c. Proto Corporation.
    d. Speedline Corporation.
    e. The Dow Chemical Company.

2.5 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Mon-Eco Industries, Inc.
    e. Vimasco Corporation.

2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
5. Color: White.

C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to 180 deg F.
4. Color: White.

D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller.
   c. Knauf Insulation.
   d. Mon-Eco Industries, Inc.
   e. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.6 LAGGING ADHESIVES

A. Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Vimasco Corporation.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range: 20 to plus 180 deg F.

4. Color: White.

2.7 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.
   d. Owens Corning.

2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 58 to plus 176 deg F.
4. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.8 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136 Types I, II, III, IV, and VII.
5. PSK Jacket: Aluminum foil fiberglass reinforced scrim with polyethylene backing, complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Airex Manufacturing Inc.
   b. Johns Manville; a Berkshire Hathaway company.
   c. P.I.C. Plastics, Inc.
   d. Proto Corporation.
   e. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. RPR Products, Inc.

2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper 3-mil-thick polysurlyn.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless Steel Jacket: ASTM A240/A240M.

a. Sheet and roll stock ready for shop or field sizing.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper 3-mil-thick, heat-bonded polyethylene and kraft paper 3-mil-thick polysurlyn.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper 2.5-mil-thick polysurlyn.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane, consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Owens Corning.
b. Polyguard Products, Inc.

F. Self-Adhesive Outdoor Jacket (Asphaltic): 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. MFM Building Products Corp.
b. Polyguard Products, Inc.

G. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket with five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M.
b. Foster Brand; H. B. Fuller Construction Products.
c. Ideal Tape Co., Inc., an American Biltrite Company.

2. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
3. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
4. Aluminum Finish: Embossed.

2.10 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Childers Brand; H. B. Fuller Construction Products.

B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Foster Brand; H. B. Fuller Construction Products.
b. Vimasco Corporation.

2.11 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Alpha Associates, Inc.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M Industrial Adhesives and Tapes Division.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M Industrial Adhesives and Tapes Division.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. 3M Industrial Adhesives and Tapes Division.
   b. Ideal Tape Co., Inc., an American Biltrite Company.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.13 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Johns Manville; a Berkshire Hathaway company.
   b. RPR Products, Inc.

2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.080-inch nickel-copper alloy.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. C & F Wire Products.
b. Johns Manville; a Berkshire Hathaway company.
c. RPR Products, Inc.

2.14 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers,:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Buckaroos, Inc.
b. MVG Molded Products.
c. McGuire Manufacturing.
d. Plumberex Specialty Products, Inc.
e. Truebro; IPS Corporation.
f. Zurn Industries, LLC.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures, Insert drawing designation:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Truebro; IPS Corporation.
b. Zurn Industries, LLC.

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the engineer-of-record.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.

a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered or routed fittings made from same material and density as that of adjacent pipe insulation. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation,

or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation conforms to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by

insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections.

B. Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order

of their installation. Extent of inspection is limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

F. All insulation applications will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/4 and Larger: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 and Smaller: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/2 and Larger: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Domestic Chilled Water (Potable):

1. All Pipe Sizes: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Stormwater and Overflow:

1. All Pipe Sizes: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

E. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

F. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation is one of the following:

   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

G. Sanitary Waste Piping Where Heat Tracing Is Installed:

1. All Pipe Sizes: Insulation is one of the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.

H. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation is one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

I. Hot Service Drains:

1. All Pipe Sizes: Insulation is one of the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

J. Hot Service Vents:

1. All Pipe Sizes: Insulation is one of the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic Water Piping:

1. All Pipe Sizes: Insulation is one of the following:
   a. Flexible Elastomeric: 2 inches thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

B. Domestic Hot and Recirculated Hot Water:

1. All Pipe Sizes: Insulation is one of the following:
   a. Flexible Elastomeric: 2 inches thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

C. Sanitary Waste Piping Where Heat Tracing Is Installed:

1. All Pipe Sizes: Insulation is the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

D. Hot Service Drains:

1. All Pipe Sizes: Insulation is the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

E. Hot Service Vents:

1. All Pipe Sizes: Insulation is the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.14 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches thick.

B. Chilled Water, All Sizes: Cellular glass, 2 inches thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. None.
2. PVC: 20 mils thick.
3. Aluminum, Smooth: 0.016 inch thick.

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC: 20 mils thick.
2. Painted Aluminum, Smooth: 0.016 inch thick.

3.17 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 220719

SECTION 220800 - COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify Division 22 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in Section 019113.

C. Commissioning requires the participation of Division 22 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Division 1. Division 22 shall be familiar with all parts of Division 1 and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 019113 – Commissioning Requirements.

B. Section 019114 – Installation Verification Procedures

C. Section 019115 – Functional Test Procedures

D. Section 017913 – Demonstration and Training Requirements

1.3 SUBMITTALS

A. Refer to Division 01 and Section 019113 for commissioning submittal requirements. Provide copies of commissioning submittal requirement to the CxA in addition to copies required by the Owner and Design Professional.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 22 shall provide all testing equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 019113 for additional equipment requirements.

PART 3 - EXECUTION

3.1 COMMISSIONING

A. General Requirements: For additional information regarding general commissioning requirements refer to Section 019913.

B. Installation contractors shall be responsible for executing and documenting equipment installation, startup and check out of systems and equipment prior to CxA scheduling the functional performance tests. Contractor shall be responsible for providing training of the Owner's maintenance personnel in accordance with requirement of Division 01.

C. Installation verification checklist for the commissioned systems and equipment shall be provided to the installation contractors by the CxA for use by the contractor in documenting the installation and startup of equipment in the commissioning process.

D. For systems and equipment components requiring a manufacturer’s representative for installation and startup, the installing contractor is responsible for attaching the startup report to the IVC provided by the CxA.

E. TAB reports required for the plumbing systems shall be provided to the CxA before functional testing is started.

3.2 GENERAL RESPONSIBILITIES

A. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors in regards to Division 22 are as follows

1. Include the cost of commissioning in the contract price.
2. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
3. Ensure acceptable representation with the means and authority to assist the CxA in the coordination and execution of the commission process.
4. Attend a commissioning scoping meeting and other meetings necessary to facilitate the Commissioning process.
5. Review commissioning plan to be provided by the CxA.
6. Assist CxA with developing a comprehensive commissioning schedule during regularly scheduled commissioning meetings.
7. Complete commissioning activities as schedule in the master construction schedule.
8. Submit completed IVC checklists and supporting documents to PM/CM. The contractor with primary responsibility to provide and install the system or equipment is responsible for ensuring that other contractors involved with the installation complete their portion of the checklist.
9. Ensure that installation and startup are complete and the system or equipment are ready for functional testing.
10. Utilize the FPT protocols to retest the system or equipment prior to actual function performance testing. Provide documentation to CxA that pretesting was performed.
11. Address current A/E punch list items before functional testing.

12. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
13. Provide skilled technicians to perform functional performance testing under the direction of the Commissioning Authority.
14. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, OPM and A/E and retest the equipment.
15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to record conditions.
16. Provide training of the Owner's maintenance and operating staff using expert qualified personnel, as specified.
17. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3.3 CONTROL CONTRACTOR RESPONSIBILITIES

A. Additional commissioning responsibilities of the controls contractor, during construction acceptance and warrant phases are:

1. Include monitoring and control of plumbing systems and equipment in the control drawing submittals
2. Complete the installation and thoroughly inspect, startup, test, adjust, calibrate and document systems, equipment devices, sensors, etc., to be connected or controlled by the building automation system. Provide documented point-to-point check out of the control system prior to functional performance testing of plumbing systems.
3. Assist and cooperate with the CxA in the following manner:

    a. Using a skilled technician who is familiar with this building, execute the functional testing of the controls system.
    b. Assist in the functional testing of all commissioned equipment.
    c. Provide two-way radios during the testing.
    d. Execute all control system trend logs.

4. Complete IVC checklists and submit with supporting documentation.

3.4 TAB CONTRACTOR RESPONSIBLITIES

A. Additional responsibilities of the TAB contractor are:

1. Balance the domestic hot water recirculation system to ensure proper water temperature to all plumbing fixtures.
2. Provide the PM/CM and CxA a draft TAB report within two weeks of completion.
3. Provide the CxA with any requested data, gathered, but not shown on the draft reports.
4. Provide a final TAB report for to the PM/CM and CxA.

3.5 TRAINING

A. Refer to Division 01 for demonstration and Training requirements.

B. The PM/CM shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

C. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems.

D. Provide the Commissioning Authority with a training plan six weeks before the planned training.

E. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

F. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

G. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment.

END OF SECTION

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Ductile-iron pipe and fittings.
3. Stainless-steel piping
4. Piping joining materials.
5. Transition fittings.
6. Dielectric fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

C. Comply with NSF 372 for low lead.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type L water tube, annealed temper.

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

E. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

F. Appurtenances for Grooved-End Copper Tubing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International.
    b. Grinnell Mechanical Products.
    c. Shurjoint Piping Products USA Inc.
    d. Victaulic Company.

2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75/B 75M copper tube or ASTM B 584 bronze castings.
3. Mechanical Couplings for Grooved-End Copper Tubing:

    a. Copper-tube dimensions and design similar to AWWA C606.
    b. Ferrous housing sections.
    c. EPDM-rubber gaskets suitable for hot and cold water.

d. Bolts and nuts.
e. Minimum Pressure Rating: 300 psig.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51.
2. Push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

E. Standard-Pattern, Push-on-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Gaskets: AWWA C111/A21.11, rubber.

F. Compact-Pattern, Push-on-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Gaskets: AWWA C111/A21.11, rubber.

G. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.

H. Appurtenances for Grooved-End, Ductile-Iron Pipe:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Shurjoint Piping Products USA Inc.
b. Smith-Cooper International.

c. Star Pipe Products.
d. Victaulic Company.

2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions that match pipe.
3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:

a. AWWA C606 for ductile-iron-pipe dimensions.
b. Ferrous housing sections.
c. EPDM-rubber gaskets suitable for hot and cold water.
d. Bolts and nuts.

2.4 STAINLESS-STEEL PIPING

A. Potable-water piping and components shall comply with NSF 61 Annex G.

B. Stainless-Steel Pipe: ASTM A 312/A 312M, with wall thickness as indicated in “Piping Applications” Article.

C. Stainless-Steel Pipe Fittings: ASTM A 815/A 815M.

D. Appurtenances for Grooved-End, Stainless-Steel Pipe:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International.
b. Shurjoint Piping Products USA Inc.
c. Victaulic Company.

2. Fittings for Grooved-End, Stainless-Steel Pipe: Stainless-steel casting with dimensions matching stainless-steel pipe.
3. Mechanical Couplings for Grooved-End, Stainless-Steel Pipe:

a. AWWA C606 for stainless-steel-pipe dimensions.
b. Stainless-steel housing sections.
c. Stainless-steel bolts and nuts.
d. EPDM-rubber gaskets suitable for hot and cold water.
e. Minimum Pressure Rating:

1) NPS 8 and Smaller: 600 psig.
2) NPS 10 and NPS 12: 400 psig.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.6 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A.Y. McDonald Mfg. Co.
b. Capitol Manufacturing Company.
c. HART Industrial Unions, LLC.
d. Jomar Valve.
e. Matco-Norca.
f. Watts; a Watts Water Technologies company.
g. Wilkins.

2. Standard: ASSE 1079.
3. Pressure Rating: 125 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Capitol Manufacturing Company.
   b. Matco-Norca.
   c. Watts; a Watts Water Technologies company.
   d. Wilkins.

2. Standard: ASSE 1079.
3. Factory-fabricated, bolted, companion-flange assembly.
4. Pressure Rating: 175 psig.
5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Pipeline Seal and Insulator, Inc.

2. Nonconducting materials for field assembly of companion flanges.
3. Pressure Rating: 150 psig.
4. Gasket: Neoprene or phenolic.
5. Bolt Sleeves: Phenolic or polyethylene.
6. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Elster Perfection Corporation.
   b. Grinnell Mechanical Products.
   c. Matco-Norca.
   d. Precision Plumbing Products.
   e. Victaulic Company.

2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. Pressure Rating and Temperature: 300 psig at 225 deg F.
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

I. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

K. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."

S. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."

T. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

G. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

H. Joint Construction for Grooved-End Steel Piping: Make joints according to AWWA C606. Roll groove ends of pipe as specified. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

I. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

J. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings, nipples and unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges,.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.
7. NPS 8: 10 feet with 3/4-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.

6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

J. Install supports for vertical stainless-steel piping every 15 feet.

K. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
    a. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    b. Fill and isolate system according to either of the following:

        1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
        2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

    c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
    d. Repeat procedures if biological examination shows contamination.
    e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be the following:

1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

D. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 10 and larger, shall be one of the following:

1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.
2. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
3. Push-on-joint, ductile-iron pipe; standard-pattern, push-on-joint fittings; and gasketed joints.
4. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

E. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:

1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.

F. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
2. Stainless-steel Schedule 10 pipe, grooved-joint fittings, and grooved joints.

G. Aboveground domestic water piping, larger than NPS 4, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
2. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
3. Push-on-joint, ductile-iron pipe; standard-pattern, push-on-joint fittings; and gasketed joints.
4. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
5. Stainless-steel Schedule 10 pipe, grooved-joint fittings, and grooved joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers for domestic water piping.
7. Outlet boxes.
8. Hose bibbs.
9. Wall hydrants.
10. Roof hydrants.
11. Drain valves.
12. Water-hammer arresters.
13. Flexible connectors.
14. Water meters.

1.2 DEFINITIONS

A. AMI: Advanced Metering Infrastructure.

B. AMR: Automatic Meter Reading.

C. FKM: A family of fluroelastomer materials defined by ASTM D1418.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Test and inspection reports.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. FEBCO; A WATTS Brand.
   c. Watts Water Technologies; a Watts company.
   d. Zurn Industries, LLC.

2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Rough bronze.

B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. MIFAB, Inc.

c. Watts Water Technologies; a Watts company.
d. Woodford Manufacturing Company.
e. Zurn Industries, LLC.

2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

C. Pressure Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Watts Water Technologies; a Watts company.
c. Zurn Industries, LLC.

2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Accessories:

a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ames Fire & Waterworks; A WATTS Brand.
b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
c. Caleffi North America.
d. FEBCO; A WATTS Brand.
e. Watts Water Technologies; a Watts company.
f. Zurn Industries, LLC.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle third of flow range.
5. Size: See schedule on P series sheets.
6. Design Flow Rate: See schedule on P series sheets.
7. Body: Bronze or stainless steel for NPS 2 and smaller; ductile or cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

9. Configuration: Designed for horizontal, straight-through flow.
10. Accessories:

    a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
    c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Hose-Connection Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    b. Watts Water Technologies; a Watts company.
    c. Woodford Manufacturing Company.
    d. Zurn Industries, LLC.

2. Standard: ASSE 1052.
3. Operation: Up to 10-foot head of water back pressure.
4. Inlet Size: NPS 3/4.
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least 3-gpm flow.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    b. Caleffi North America.
    c. Watts Water Technologies; a Watts company.
    d. Zurn Industries, LLC.

2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
5. End Connections: Threaded or solder for NPS 2 and smaller; flanged or solder for NPS 2-1/2 and larger.

2.6 BALANCING VALVES

A. Automatic Flow Control Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Caleffi North America.
    b. IMI Hydronic Engineering Inc.
    c. ThermOmegaTech.

2. Flow Regulation: Plus or minus 5 percent over 95 percent of the working range.
3. Pressure Rating: 200 psig.
4. Size: NPS 2 or smaller.
5. Body: Stainless steel or brass.
6. Flow Cartridge: Stainless steel or antiscale polymer.
7. End Connections: Threaded or solder joint.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Acorn Engineering Company; a Division of Morris Group International.
    b. Lawler Manufacturing Company, Inc.
    c. POWERS; A WATTS Brand.
    d. Symmons Industries, Inc.
    e. Watts Water Technologies; a Watts company.

2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 110 deg F.
9. Tempered-Water Design Flow Rate: See schedules on P series sheets.
10. Pressure Drop at Design Flow Rate: See schedules on P series sheets.
11. Valve Finish: Rough bronze.
12. Piping Finish: Copper.

B. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Acorn Engineering Company; a Division of Morris Group International.
    b. Lawler Manufacturing Company, Inc.
    c. POWERS; A WATTS Brand.
    d. Zurn Industries, LLC.

2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Material: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Connections: Threaded inlets and outlet.
7. Finish: Chrome plated.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Keckley Company.
    b. Watts Water Technologies; a Watts company.
    c. Zurn Industries, LLC.

2. Pressure Rating: 125 psig minimum unless otherwise indicated.
3. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
5. Screen: Stainless steel with round perforations unless otherwise indicated.
6. Perforation Size:

    a. Strainers NPS 2 and Smaller: 0.033 inch.
    b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
    c. Strainers NPS 5 and Larger: 0.125 inch.

7. Drain: Factory-installed, hose-end drain valve.

2.9 SHUT-OFF VALVE BOXES

A. Shut-off Valve Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Guy Gray, IPS Corporation.
    b. LSP Products Group.
    c. Oatey Co.
    d. Water-Tite, IPS Corporation.

2. Mounting: Recessed.
3. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.

4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Accessory: Water hammer arrestor.
6. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.10 HOSE BIBBS

A. Hose Bibbs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. MIFAB, Inc.
    b. Watts Water Technologies; a Watts company.
    c. Woodford Manufacturing Company.
    d. Zurn Industries, LLC.

2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig.
8. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Service Areas: Rough bronze.
11. Finish for Finished Rooms: Chrome or nickel plated.
12. Operation for Equipment Rooms: Wheel handle or operating key.
13. Operation for Service Areas: Wheel handle.
14. Operation for Finished Rooms: Operating key.
15. Include operating key with each operating-key hose bibb.
16. Include wall flange with each chrome- or nickel-plated hose bibb.

2.11 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. MIFAB, Inc.
    b. Watts Water Technologies; a Watts company.
    c. Woodford Manufacturing Company.
    d. Zurn Industries, LLC.

2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.

3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet, Concealed: With integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.

2.12 ROOF HYDRANTS

A. Nonfreeze, Draining-Type Roof Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. MIFAB, Inc.
    b. Watts Water Technologies; a Watts company.
    c. Woodford Manufacturing Company.
    d. Zurn Industries, LLC.

2. Standard: ASME A112.21.3M.
3. Type: Nonfreeze, exposed-outlet roof hydrant with coated cast-iron head and lift handle with lock option. Provide with deck flange and under deck clamp.
4. Casing and Operating Rod: Bronze interior parts, galvanized-steel casing, and bronze valve housing designed with hole to drain.
5. Inlet: NPS 3/4.
6. Outlet: Garden-hose thread complying with ASME B1.20.7.
7. Vacuum Breaker:

    a. Nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
    b. Garden-hose thread complying with ASME B1.20.7 on outlet.

2.13 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.

9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.14 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AMTROL, Inc.
b. MIFAB, Inc.
c. Precision Plumbing Products.
d. Watts Water Technologies; a Watts company.
e. Zurn Industries, LLC.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Diaphragm.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.15 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flex-Hose Co., Inc.
2. Mason Industries, Inc.
3. Metraflex Company (The).

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

C. Stainless Steel-Hose Flexible Connectors: Corrugated-stainless steel tubing with stainless steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

2.16 WATER METERS

A. Displacement-Type Water Meters:

1. Standard: AWWA C700.
2. Pressure Rating: 150-psig working pressure.
3. Body Design: Nutating disc; totalization meter.
4. Registration: In gallons or cubic feet as required by utility company.

    a. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

        1) System shall be capable of transmitting data using AMR/AMI technology.

5. Case: Stainless steel.
6. End Connections: Threaded or flanged.

B. Turbine-Type Water Meters:

1. Standard: AWWA C701.
2. Pressure Rating: 150 psig working pressure.
3. Body Design: Turbine; totalization meter.
4. Registration: In gallons or cubic feet as required by utility company.

    a. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

        1) System shall be capable of transmitting data using AMR/AMI technology.

5. Case: Bronze.

6. End Connections: Threaded or flanged.

C. Compound-Type Water Meters:

1. Standard: AWWA C702.
2. Pressure Rating: 150-psig working pressure.
3. Body Design: With integral mainline and bypass meters; totalization meter.
4. Registration: In gallons or cubic feet as required by utility company.

a. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

1) System shall be capable of transmitting data using AMR/AMI technology.

5. Case: Bronze.
6. End Connections: Flanged.

D. Ultrasonic-Type Water Meters:

1. Standard: Applicable portions of AWWA C700.
2. Pressure Rating: 150 psig working pressure.
3. Body Design: Ultrasonic open flow tube; totalization meter.
4. Registration: In gallons or cubic feet as required by utility company.

a. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

1) System shall be capable of transmitting data using AMR/AMI technology.

5. Case: Stainless steel.
6. End Connections: Threaded or flanged.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

A. Backflow Preventers: Install in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap

device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.

3. Do not install bypass piping around backflow preventers.

B. Water Regulators: Install with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.

C. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.

D. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Y-Pattern Strainers: For water, install on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

F. Outlet Boxes: Install boxes recessed in wall or surface mounted on wall. Install 1-1/2-by-3-1/2-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."

1. Fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."

G. Nonfreeze, Draining-Type Roof Hydrants: Install with drain connection piped to nearest floor drain or to the exterior.

H. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.

3.2 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

3.4 CONTROL CONNECTIONS

A. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.5 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Outlet boxes.
7. Wall hydrants.
8. Roof hydrants.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.6 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

D. Adjust each pressure vacuum breaker and reduced-pressure-principle backflow preventer in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Test each pressure vacuum breaker and reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 221119

SECTION 221123.13 - DOMESTIC-WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Multiplex, variable-speed booster pumps.

1.3 DEFINITIONS

A. VFC: Variable-frequency controller(s).

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Booster pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the booster pump will remain in place without separation of any parts from the booster pump when subjected to the seismic forces specified and the booster pump will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For booster pumps. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For booster pumps, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For booster pumps to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Comply with ASME B31.9 for piping.

C. UL Compliance for Packaged Pumping Systems:

1. UL 508, "Industrial Control Equipment."
2. UL 508A, "Industrial Control Panels."
3. UL 778, "Motor-Operated Water Pumps."
4. UL 1995, "Heating and Cooling Equipment."

D. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Retain protective coatings and flange's protective covers during storage.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 MULTIPLEX, VARIABLE-SPEED BOOSTER PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armstrong Fluid Technology.
2. Bell & Gossett; a Xylem brand.
3. Goulds Water Technology; a Xylem brand.
4. Grundfos Pumps Corporation.
5. QuantumFlo, Inc.
6. TIGERFLOW Systems, Inc. – basis of design

B. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.

C. Pumps:

1. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
2. Casing: Cast-iron or steel base and stainless-steel chamber.
3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
4. Shaft: Stainless steel.
5. Seal: Mechanical.
6. Bearing: Water-lubricated sleeve type.

D. Motors: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings. Select motors that will not overload through full range of pump performance curve.

E. Piping: Stainless-steel pipe and fittings.

F. Valves:

1. Shutoff Valves NPS 2 and smaller: Two-piece, full-port ball valve, in each pump's suction and discharge piping and in inlet and outlet headers.
2. Shutoff Valves NPS 2-1/2 and Larger: Gate valve or lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers.
3. Check Valves NPS 2 and smaller: Silent or swing type in each pump's discharge piping.
4. Check Valves NPS 2-1/2 and Larger: Silent type in each pump's discharge piping.
5. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.

G. Dielectric Fittings: With insulating material isolating joined dissimilar metals.

H. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, variable-speed operation, with load control and protection functions.

1. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in controller. Install VFC for pump motors larger than 25 hp in separate panel; same type as motor control panel enclosure.
2. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type.

    a. Control Voltage: 120-V ac, with integral control-power transformer.

3. Enclosure: NEMA 250, Type 1.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.

    a. Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.
    b. Quadraplex, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.

6. Pump Operation and Sequencing: Pressure-sensing method or flow-sensing method.

    a. Manufacturer to provide remote pressure sensor.
    b. Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.

7. VFC: Voltage-source, pulse-width, modulating-frequency converter for each pump.
8. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.
9. Instrumentation: Suction and discharge pressure gages.
10. Lights: Running light for each pump.
11. Alarm Signal Device: Sounds alarm when backup pumps are operating.

    a. Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic reset.

12. Thermal-bleed cutoff.
13. Low-suction-pressure cutout.
14. High-suction-pressure cutout.
15. Low-discharge-pressure cutout.
16. High-discharge-pressure cutout.

17. Direct Digital Control (DDC) System for HVAC: Provide auxiliary contacts for interface to BACnet DDC system. DDC systems are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Include the following:

    a. On-off status of each pump.
    b. Alarm status.

I. Base: Structural steel.

J. Capacities and Characteristics:

1. Minimum Pressure Rating: 150 psig.
2. For pump capacities see schedule on P series drawings.

K. Manufacturer to provide Bacnet interface.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

3.2 INSTALLATION

A. Equipment Mounting:

1. Install booster pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"

3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers.

1. Install shutoff valves on piping connections to booster-pump suction and discharge headers. Install ball, butterfly, or gate valves same size as suction and discharge headers. Comply with requirements for general-duty valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Install union, flanged, or grooved-joint connections on suction and discharge headers at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Section 221116 "Domestic Water Piping."
3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge piping. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."
4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge piping. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."
5. Install piping adjacent to booster pumps to allow service and maintenance.

3.4 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Perform visual and mechanical inspection.
2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Adjust booster pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust pressure set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 221123.13

SECTION 221123.21 - INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Horizontally mounted, in-line, close-coupled centrifugal pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction materials, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail pumps and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which pumps will be attached.
2. Size and location of initial access modules for acoustical tile.

B. Seismic Qualification Data: Certificates, for inline, domestic-water pumps, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For inline, domestic-water pumps to include in operation and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: UL 778 for motor-operated water pumps.

C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

D. Seismic Performance: Inline, domestic-water pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: 1.5.

2.2 HORIZONTALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bell & Gossett; a Xylem brand.
2. Grundfos.
3. Pentair Aurora; Pentair Pump Group.
4. Taco Comfort Solutions.

C. Capacities and Characteristics:

1. Capacity: See schedule on P series drawings.

D. Pump Construction:

1. Casing:

a. Radially split bronze with threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
b. Built to permit servicing of pump internals without disturbing the casing or the suction and discharge piping.
c. Gauge port tappings at suction and discharge nozzles.

2. Impeller: Bronze or brass, statically and dynamically balanced, closed, and keyed to shaft.
3. Shaft and Shaft Sleeve: Steel shaft with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
4. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
5. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
6. Bearings: Grease-lubricated or permanently lubricated ball type.
7. Minimum Working Pressure: 175 psig.
8. Continuous Operating Temperature: 225 deg F.

E. Motor: Single speed, with grease-lubricated ball bearings; resiliently or rigidly mounted to pump casing.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.4 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 deg F.
3. Enclosure: NEMA 250, Type 4X.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement: 120 V ac.
7. Settings: Start pump at 110 deg F and stop pump at 120 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for domestic-water-piping system to verify actual locations of piping connections before pump installation.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Mount pumps in orientation complying with manufacturer's written instructions.

C. Pump Mounting:

1. Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using vibration isolation type and deflection as specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment." Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.

1. Comply with requirements for vibration isolation devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

E. Install thermostats in hot-water return piping.

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.

C. Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.

1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
   a. Horizontally mounted, in-line, close-coupled centrifugal pumps.
   b. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."

D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in the following:

1. Section 220523.12 "Ball Valves for Plumbing Piping."
2. Section 220523.13 "Butterfly Valves for Plumbing Piping."
3. Section 220523.14 "Check Valves for Plumbing Piping."
4. Section 220523.15 "Gate Valves for Plumbing Piping."
5. Install pressure gauge and snubber at suction of each pump and pressure gauge mand snubber at discharge of each pump. Install at integral pressure-gauge tappings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 220519 "Meters and Gages for Plumbing Piping."

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between temperature controllers and devices.

C. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats, for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

6. Prime pump by opening suction valves and closing drains and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.8 ADJUSTING

A. Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123.21

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Stainless steel drainage pipe and fittings.
4. Copper tube and fittings.
5. PVC pipe and fittings.
6. Specialty pipe fittings.
7. Encasement for underground metal piping.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and elevations or Building Information Model (BIM) drawn to scale, showing items described in this Section and coordinated with all building trades.

B. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.4 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then

only after arranging to provide temporary service in accordance with requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

1.5 WARRANTY

A. Listed manufacturers to provide labeling and warranty of their respective products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation are capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10 ft. head of water.
2. Waste, Force-Main Piping: 100 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment":

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

2.2 PIPING MATERIALS

A. Piping materials to bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings:

1. Marked with CISPI collective trademark.
2. ASTM A74, service cast iron.
3. Each pipe and fitting shall be marked with size, country of origin, name of manufacturer or trademark.
4. Coating performances on pipe and fittings must pass the performance specifications per EN 877.

C. Gaskets: ASTM C564, rubber.

D. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

E. Epoxy coating for pipe and fittings shall be high-performance anodic epoxy with thickness of 5 mils or greater on both ID and OD.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings:

1. Marked with CISPI collective trademark and listed by NSF International
2. ASTM A888 or CISPI 301.
3. Each pipe and fitting shall be marked with size, country of origin, name of manufacturer or trademark.
4. Epoxy coating for pipe and fittings shall be high-performance anodic epoxy with thickness of 5 mils or greater on both ID and OD.
5. Coating performances on pipe and fittings must pass the performance specifications per EN 877.

C. Mid-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky “SD 2000”
   b. Charlotte Pipe and Foundry Company “Ideal MD”.
   c. Mission Rubber Company, LLC; a division of MCP Industries “HW”.
   d. Tyler Pipe; a subsidiary of McWane Inc “WB”.

2. Standards: ASTM C1277 and ASTM C1540.
3. Description: Stainless steel shield with minimum (4) stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.5 STAINLESS STEEL DRAINAGE PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
2. BLÜCHER; A Watts brand.
3. Josam Company.

B. Description: Comply with requirements of ASME A112.3.1 drainage pattern.

C. Material: Type 304 or 316L stainless steel.

D. Pipe Construction: Seamless.

E. Internal Sealing Rings: EPDM.

F. Joints: Single or double, socket and spigot ends.

2.6 COPPER TUBE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cambridge-Lee Industries, LLC.
2. Cerro Flow Products, LLC.
3. Wieland Copper Products, LLC.

B. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.

C. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

D. Hard Copper Tube: ASTM B88, Type L, water tube, drawn temper.

E. Soft Copper Tube: ASTM B88, Type L, water tube, annealed temper.

F. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

G. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

H. Solder: ASTM B32, lead free with ASTM B813, water-flushable flux.

2.7 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections of same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

3. Shielded, Nonpressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cascade Waterworks Mfg. Co.
2) Mission Rubber Company, LLC; a division of MCP Industries.

b. Standard: ASTM C1460.
c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. End Connections: Same size as and compatible with pipes to be joined.

4. Pressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Apollo Valves; a part of Aalberts Integrated Piping Systems.
2) Cascade Waterworks Mfg. Co.
3) EBAA Iron Sales, Inc.
4) Ford Meter Box Company, Inc. (The).
5) JCM Industries, Inc.
6) Romac Industries, Inc.

b. Standard: AWWA C219.
c. Description: Metal sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
d. Center-Sleeve Material: Malleable iron.

e. Gasket Material: Natural or synthetic rubber.
f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) GF Piping Systems: Georg Fischer LLC.
2) HART Industrial Unions, LLC.
3) Jomar Valve.
4) Matco-Norca.
5) Watts Water Technologies; a Watts company.
6) Wilkins.
7) Zurn Industries, LLC.

b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 150 psig.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Matco-Norca.
2) Watts Water Technologies; a Watts company.
3) Zurn Industries, LLC.

b. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 150 psig.
4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Advance Products & Systems, LLC.

2) CALPICO, Inc.
3) GF Piping Systems: Georg Fischer LLC.
4) GPT; a division of EnPRO Industries.

b. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig.
3) Gasket: Neoprene or phenolic.
4) Bolt Sleeves: Phenolic or polyethylene.
5) Washers: Phenolic with steel backing washers.

5. Dielectric Nipples:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
2) Elster Perfection; Honeywell.
3) Matco-Norca.
4) Precision Plumbing Products.
5) Victaulic Company.

b. Description:

1) Standard: IAPMO PS 66.
2) Electroplated steel nipple.
3) Pressure Rating: 300 psig at 225 deg F.
4) End Connections: Male threaded or grooved.
5) Lining: Inert and noncorrosive, propylene.

2.8 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A674 or AWWA C105/A 21.5.

B. Material: high-density, cross-laminated polyethylene film of 0.004-inch minimum thickness.

C. Form: tube.

D. Color: Black.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment".

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch, and 1/8-bend fittings if two fixtures are installed back-to-back or side by side with common drain pipe.

a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

a. Reducing size of waste piping in direction of flow is prohibited.

L. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste Piping: Two percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.
2. Vent Piping: One percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping in accordance with ASTM A674 or AWWA C105/A 21.5.

O. Install steel piping in accordance with applicable plumbing code.

P. Install stainless-steel piping in accordance with ASME A112.3.1 and applicable plumbing code.

Q. Install aboveground copper tubing in accordance with CDA's "Copper Tube Handbook."

R. Install engineered soil and waste and vent piping systems as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

S. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping.

a. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."

2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
b. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."

3. Install drains in sanitary waste gravity-flow piping.

a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hub-and-Spigot, Cast-Iron Soil Piping Caulked Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.

C. Hubless, Cast-Iron Soil Piping Coupled Joints:

1. Join hubless, cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1.

1. Cut threads full and clean using sharp dies.
2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

    a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
    b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
    c. Do not use pipe sections that have cracked or open welds.

E. Join stainless-steel pipe and fittings with gaskets in accordance with ASME A112.3.1.

F. Join copper tube and fittings with soldered joints in accordance with ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.

G. Grooved Joints: Cut groove ends of pipe in accordance with AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

H. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

I. Joint Restraints and Sway Bracing:

1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:

    a. Provide axial restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
    b. Provide rigid sway bracing for pipe and fittings 4 inches and larger, upstream and downstream of all changes in direction 45 degrees and greater.
    c. Provide rigid sway bracing for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction and branch openings.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:

    a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
    b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. General valve installation requirements for general-duty valve installation are specified in the following Sections:

1. Section 220523.12 "Ball Valves for Plumbing Piping."
2. Section 220523.13 "Butterfly Valves for Plumbing Piping."
3. Section 220523.14 "Check Valves for Plumbing Piping."
4. Section 220523.15 "Gate Valves for Plumbing Piping."

B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install full-port ball valve for piping NPS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment".

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42 clamps.
6. Install individual, straight, horizontal piping runs:

    a. 100 Ft. and Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer Than 100 Ft.: MSS Type 43, adjustable roller hangers.
c. Longer Than 100 Ft. if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Ft. or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52 spring hangers.

C. Install hangers for cast-iron, steel, stainless steel, and copper soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

E. Support vertical runs of cast-iron, steel, stainless steel, and copper soil piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
6. Equipment: Connect waste piping as indicated.

a. Provide shutoff valve if indicated and union for each connection.
b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections in accordance with the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping in accordance with procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

    a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

    a. Close openings in piping system and fill with water to point of overflow, but not less than 10 ft. head of water.
    b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.

c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

   a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1 inch wg.
   b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
   c. Air pressure must remain constant without introducing additional air throughout period of inspection.
   d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smaller are to be any of the following:

1. Service cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Stainless steel pipe and fittings, sealing rings, and gasketed joints.
4. Copper Type DWV tube, copper drainage fittings, and soldered joints.
5.
6. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Aboveground, soil and waste piping NPS 5 and larger are to be any of the following:

1. Service cast iron, cast-iron soil pipe and fittings; gaskets; and gasketed joints.

2. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.
3. Stainless steel pipe and fittings, sealing rings, and gasketed joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Aboveground, vent piping NPS 4 and smaller is to be any of the following:

1. Service cast iron, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Stainless steel pipe and fittings gaskets, and gasketed joints.
4. Copper Type DWV tube, copper drainage fittings, and soldered joints.

    a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.
5. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

E. Aboveground, vent piping NPS 5 and larger is to be any of the following:

1. Service cast iron, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

F. Underground, soil, waste, and vent piping NPS 4 and smaller are to be any of the following:

1. Service cast-iron soil piping; gaskets; and gasketed joints.
2. Stainless steel pipe and fittings, gaskets, and gasketed joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

G. Underground, soil and waste piping NPS 5 and larger are to be any of the following:

1. Extra-heavy, cast-iron soil piping; gaskets; and gasketed joints.
2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Cleanouts.
2. Miscellaneous sanitary drainage piping specialties.

B. Related Requirements:

1. Section 076200 "Sheet Metal Flashing and Trim" for metal roof flashing assemblies.
2. Section 077200 "Roof Accessories" for preformed flashings.
3. Section 078413 "Penetration Firestopping" for through-penetration firestop assemblies.

1.3 DEFINITIONS

A. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show fabrication and installation details for frost-resistant vent terminals.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Josam Company.
   b. MIFAB, Inc.
   c. Tyler Pipe; a subsidiary of McWane Inc.
   d. Watts Water Technologies; a Watts company.
   e. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, cast-iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Josam Company.
   b. MIFAB, Inc.
   c. Watts Water Technologies; a Watts company.
   d. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.

4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top-Loading Classification: Heavy Duty.
13. Riser: ASTM A74, Service Class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Josam Company.
    b. MIFAB, Inc.
    c. Watts Water Technologies; a Watts company.
    d. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure Plug:

    a. Brass.
    b. Countersunk or raised head.
    c. Drilled and threaded for cover attachment screw.
    d. Size: Same as or not more than one size smaller than cleanout size.

6. Wall Access, Cover Plate: Round, flat, chrome-plated brass or stainless steel cover plate with screw.
7. Wall Access, Frame and Cover: Round, nickel-bronze, copper-alloy, or stainless steel wall-installation frame and cover.

2.3 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.

    a. NPS 2: 4-inch-minimum water seal.
    b. NPS 2-1/2 and Larger: 5-inch-minimum water seal.

B. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Floor-Drain, Inline Trap Seal:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Green Drain, Inc.
   b. Jay R. Smith Mfg Co; a division of Morris Group International.
   c. Josam Company.
   d. MIFAB, Inc.
   e. RectorSeal Plumbing; A CSW Industrials Company.

2. Description: Inline floor drain trap seal, forming a physical barrier to slow trap evaporation while not impeding flow from drain.
3. Material: Polymer.
4. Standard: Tested and certified in accordance with ASSE 1072.
5. Listing: ICC-ES or IAPMO listed.
6. Size: Same as floor drain outlet or strainer throat.

D. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

H. Frost-Resistant Vent Terminals:

1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

I. Expansion Joints:

1. Standard: ASME A112.6.4.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Assemble open drain fittings and install with top of hub 2 inches above floor.

E. Install deep-seal traps on floor drains and other waste outlets, if indicated.

F. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

H. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

I. Install vent caps on each vent pipe passing through roof.

J. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

K. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

L. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

M. Install wood-blocking reinforcement for wall-mounting-type specialties.

N. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, to allow service and maintenance.

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

1. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

SECTION 221319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Floor drains.
2. Floor sinks.
3. Trench drain grates and frames.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. HDPE: High-density polyethylene.

C. PE: Polyethylene.

D. PP: Polypropylene.

E. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Jay R. Smith Mfg Co; a division of Morris Group International.
    b. Josam Company.
    c. MIFAB, Inc.
    d. Sioux Chief Mfg. Co., Inc.
    e. Wade; a subsidiary of McWane Inc.
    f. WATTS.
    g. Zurn Industries, LLC.

2. Standard: ASME A112.6.3.
3. Pattern: Area Floor drain.
4. Body Material: Gray iron or cast iron.
5. Seepage Flange: Not required.
6. Anchor Flange: Not required.
7. Clamping Device: Not required.
8. Outlet: Bottom.
9. Sediment Bucket: Not required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.
12. Top Shape: Round.
13. Top Loading Classification: Medium Duty.

2.3 FLOOR SINKS

A. Cast-Iron Floor Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Jay R. Smith Mfg Co; a division of Morris Group International.
    b. Josam Company.
    c. Sioux Chief Mfg. Co., Inc.
    d. Wade; a subsidiary of McWane Inc.
    e. WATTS.
    f. Zurn Industries, LLC.

2. Standard: ASME A112.6.7.
3. Pattern: Floor drain.
4. Body Material: Cast iron.
5. Coating on Interior Surfaces: Acid-resistant enamel.
6. Sediment Bucket: Required.

7. Internal Strainer: Dome.
8. Top Grate Material: Cast iron.
9. Top of Body and Grate Finish: Acid-resistant enamel.
10. Top Shape: Square.
11. Top Loading Classification: Heavy Duty.

2.4 TRENCH DRAIN GRATES AND FRAMES

A. Trench Drain Grates And Frames:

1. Manufacturer: Neenah Foundry.
2. Standard: ASTM A-48, Class 35-A and 35-B.
3. Clamping Device: Unbolted.
4. Grate Material: Ductile iron or gray iron.
5. Grate Finish: Black.
6. Dimensions of Frame and Grate: See Drainage Fixture Schedule and plumbing floor plans.
7. Top Loading Classification: Heavy Duty.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:

    a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
    c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.

    a. Maintain integrity of waterproof membranes where penetrated.

5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

B. Install open drain fittings with top of hub 2 inches above floor.

C. Install trench drain grates where indicated in tunnel.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Install piping adjacent to equipment to allow service and maintenance.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

SECTION 221414 - STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Specialty pipe fittings.
4. Encasement for underground metal piping.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Specialty pipe fittings.

B. Shop Drawings: For controlled-flow roof drainage system. Include calculations, plans, sections, elevations, and details.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and elevations or Building Information Model (BIM) drawn to scale, showing items described in this Section and coordinated with all building trades.

B. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certificate is based and their installation requirements.

C. Field Quality-Control Reports: Inspection reports signed by authorities having jurisdiction.

1.4 QUALITY ASSURANCE

A. Provide materials bearing label, stamp, or other markings of specified testing agency.

1.5 FIELD CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of storm drainage service.
2. Do not proceed with interruption of storm drainage service without Owner's written permission.

1.6 WARRANTY

A. Listed manufacturers to provide labeling and warranty of their respective products

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation are to be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water.
2. Storm Drainage, Force-Main Piping: 100 psig.

B. Seismic Performance: Storm drainage piping and support and installation to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully functional after the seismic event."
2. Component Importance Factor: 1.5.

2.2 PIPING MATERIALS

A. Piping materials to bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Standard: ASTM A74.
3. Class: Service weight and Extra heavy cast iron.

C. Gaskets: ASTM C564, rubber.

D. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Standards: ASTM A888 and CISPI 301.
3. Each pipe and fitting shall be marked with size, country of origin, name of manufacturer or trademark.
4. Epoxy coating for pipe and fittings shall be high-performance anodic epoxy with thickness of 5 mils or greater on both ID and OD.
5. Coating performances on pipe and fittings must pass the performance specifications per EN 877.

C. Mid-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ANACO-Husky “SD 2000”.
b. Charlotte Pipe and Foundry Company “Ideal MD”.
c. Mission Rubber Company, LLC; a division of MCP Industries “HW”.
d. Tyler Pipe; a subsidiary of McWane Inc “WB”.

2. Marked with CISPI collective trademark and NSF certification mark.
3. Standards: ASTM C1277 and CISPI 310.
4. Description: Stainless steel shield with minimum (4) stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections of same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Unshielded, Nonpressure Transition Couplings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Dallas Specialty & Mfg. Co.
        2) Mission Rubber Company, LLC; a division of MCP Industries.

    b. Standard: ASTM C1173.
    c. Description: Elastomeric sleeve, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
    d. Sleeve Materials:

        1) For Cast-Iron Soil Pipes: ASTM C564 rubber.
        2) For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926 PVC.
        3) For Dissimilar Pipes: ASTM D5926 PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Dallas Specialty & Mfg. Co.
        2) Mission Rubber Company, LLC; a division of MCP Industries.

    b. Standard: ASTM C1460.
    c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
    d. End Connections: Same size as and compatible with pipes to be joined.

5. Pressure Transition Couplings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Cascade Waterworks Mfg. Co.
        2) EBAA Iron Sales, Inc.
        3) Ford Meter Box Company, Inc. (The).
        4) JCM Industries, Inc.
        5) Romac Industries, Inc.

    b. Standard: AWWA C219.
    c. Description: Metal, sleeve-type couplings same size as pipes to be joined, and with pressure rating at least equal to and ends compatible with pipes to be joined.
    d. Center-Sleeve Material: Manufacturer's standard.
    e. Gasket Material: Natural or synthetic rubber.
    f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) A.Y. McDonald Mfg. Co.
        2) HART Industrial Unions, LLC.
        3) Jomar Valve.
        4) Watts Water Technologies; a Watts company.
        5) Zurn Industries, LLC.

    b. Description:

        1) Standard: ASSE 1079.
        2) Pressure Rating: 150 psig minimum at 180 deg F.
        3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

    a. Manufacturers: Subject to compliance with requirements, provide products by the following:

        1) Watts Water Technologies; a Watts company.

    b. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 150 psig minimum at 180 deg F.
4) End Connections: Solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Advance Products & Systems, LLC.
2) GPT; an EnPro Industries company.

b. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig.
3) Gasket: Neoprene or phenolic.
4) Bolt Sleeves: Phenolic or polyethylene.
5) Washers: Phenolic with steel-backing washers.

5. Dielectric Nipples:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
2) Matco-Norca.
3) Precision Plumbing Products.

b. Description: Electroplated steel nipple.
c. Standards: ASTM F492, ASME B1.20.1.
d. Pressure Rating: 300 psig at 225 deg F.
e. End Connections: Male threaded or grooved.
f. Lining: Inert and noncorrosive, propylene.

2.6 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A674 or AWWA C105/A 21.5.

B. Material: High-density, cross laminated polyethylene film of 0.004-inch or linear low-density polyethylene film of 0.008-inch minimum thickness.

C. Form: Sheet or tube.

D. Color: Black or natural.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

B. Install piping as indicated unless deviations from layout are approved on coordination drawings.

C. Install piping in concealed locations.

1. Piping installed in equipment rooms, service areas, and where indicated may be exposed.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

L. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.

1. Do not change direction of flow more than 90 degrees.
2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

a. Reducing size of drainage piping in direction of flow is prohibited.

M. Lay buried building piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

N. Install piping at the following minimum slopes unless otherwise indicated.

1. Building Storm Drain: 1/4 inch per foot downward in direction of flow for piping NPS 3 and smaller; 1/8 inch per foot downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm Drainage Piping: 1/4 inch per foot downward in direction of flow.

O. Install cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Ch IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping in accordance with ASTM A674 or AWWA C105/A 21.5.

P. Install steel piping in accordance with applicable plumbing code.

Q. Install engineered controlled-flow drain specialties and storm drainage piping in locations indicated.

1. Install encasement on piping in accordance with ASTM A674 or AWWA C105/A 21.5.

R. Install force mains at elevations indicated.

S. Plumbing Specialties:

1. Install backwater valves in storm drainage gravity-flow piping.

a. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."

2. Install cleanouts in storm drainage gravity-flow piping in accessible locations.

a. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
b. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."

3. Install drains in storm drainage gravity-flow piping.

a. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."

T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

X. When Epoxy coated cast iron pipe is cut in the field, apply approved manufactured Epoxy paint on exposed edges before installation.

3.3 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hub-and-Spigot, Cast-Iron Soil Piping Caulked Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.

C. Hubless, Cast-Iron Soil Piping Coupled Joints: Join in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1.

1. Cut threads full and clean using sharp dies.
2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

a. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
c. Do not use pipe sections that have cracked or open welds.

E. Grooved Joints: Cut groove ends of pipe in accordance with AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fittings. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

F. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

G. Joint Restraints and Sway Bracing:

1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:

a. Provide axial restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
b. Provide rigid sway bracing for pipe and fittings 4 inches and larger, upstream and downstream of all changes in direction 45 degrees and greater.
c. Provide rigid sway bracing for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction and branch openings.

3.4 INSTALLATION OF SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Drainage Piping: Shielded, nonpressure transition couplings.
3. In Aboveground Force-Main Piping: Fitting-type transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 INSTALLATION OF VALVES.

A. General valve installation requirements for general-duty valve installations are specified in the following Sections:

1. Section 220523.12 "Ball Valves for Plumbing Piping."
2. Section 220523.13 "Butterfly Valves for Plumbing Piping."
3. Section 220523.14 "Check Valves for Plumbing Piping."
4. Section 220523.15 "Gate Valves for Plumbing Piping."

B. Shutoff Valves:

1. Install shutoff valve on each sump pump discharge.
2. Install full port ball valve for piping NS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Install backwater valves in accessible locations.
3. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install hangers for cast-iron or galvanized-steel piping with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

E. Support vertical cast-iron or galvanized steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent, but as a minimum at base and at each floor.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

1. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
2. Install horizontal backwater valves with cleanout cover flush with floor.
3. Comply with requirements for cleanouts and drains specified in Section 221423 "Storm Drainage Piping Specialties."

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections in accordance with the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed storm drainage piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping in accordance with procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.

a. Expose work that was covered or concealed before it was tested.

3. Test Procedure:

a. Test storm drainage piping, except outside leaders, on completion of roughing-in.
b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
c. From 15 minutes before inspection starts until completion of inspection, water level must not drop.
d. Inspect joints for leaks.

4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.10 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

3.11 PROTECTION

A. Protect piping and drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day and when work stops.

C. Repair damage to adjacent materials caused by storm drainage piping installation.

3.12 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground storm drainage piping NPS 6 and smaller is to be any of the following:

1. Service weight, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Aboveground, storm drainage piping NPS 8 and larger is to be any of the following:

1. Service weight, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Underground storm drainage piping NPS 6 and smaller shall be any of the following:

1. Service weight, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI, heavy duty, cast-iron, hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

E. Underground, storm drainage piping NPS 8 and larger is to be any of the following:

1. Extra heavy, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, cast-iron, hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 221414

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-purpose roof drains.
2. Deck roof drains
3. Miscellaneous storm drainage piping specialties.
4. Cleanouts.

B. Related Requirements:

C. Product Data:

1. General-purpose roof drains.
2. Deck roof drains.
3. Miscellaneous storm drainage piping specialties.
4. Cleanouts.

1.2 QUALITY ASSURANCE

A. Provide drainage piping specialties are to bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 GENERAL-PURPOSE ROOF DRAINS

A. Cast-Iron Roof Drains:

1. Cast-Iron, Large-Sump, General-Purpose Roof Drains:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Josam Company.
2) MIFAB, Inc.
3) Wade; a subsidiary of McWane Inc.
4) Watts Water Technologies; a Watts company.
5) Zurn Industries, LLC.

b. Standard: ASME A112.6.4.
c. Body Material: Cast iron.
d. Dimension of Body: Nominal 14-to 16-inch diameter.
e. Dome Material: Cast iron.
f. Combination flashing ring and gravel stop.
g. Outlet: Bottom.
h. Outlet Type: No-hub.
i. Options:

1) Flow-control weirs.
2) Extension collars.
3) Underdeck clamp.
4) Expansion joint.
5) Sump receiver plate.
6) Perforated Gravel Guard: Stainless steel.
7) Vandal-proof dome.
8) Water Dam: 2 inches high.

2.2 DECK ROOF DRAINS

A. Cast-Iron Deck Roof Drains:

1. Cast-Iron, Medium-Sump, Deck Roof Drains:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) MIFAB, Inc.
2) Watts Water Technologies; a Watts company.
3) Zurn Industries, LLC.

b. Standard: ASME A112.6.4.
c. Body Material: Cast iron.
d. Overall Dimension of Frame and Grate: Nominal 12 to 14 inches round.
e. Top-Loading Classification: Heavy Duty.
f. Grate Material: Cast or ductile iron.
g. Flange: Anchor.
h. Outlet: Bottom.
i. Outlet Type: No-hub.
j. Options:

1) Clamping device.
2) Grate Finish: Nickel Bronze.
3) Vandal-proof frame and grate.

2.3 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Cast-Iron Exposed Cleanouts:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) MIFAB, Inc.
        2) Wade; a subsidiary of McWane Inc.
        3) Watts Water Technologies; a Watts company.
        4) Zurn Industries, LLC.

    b. Standard: ASME A112.36.2M.
    c. Size: Same as connected branch.
    d. Body Material: No-hub, cast-iron soil pipe test tee as required to match connected piping.
    e. Closure: Countersunk or raised-head, cast-iron plug.
    f. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

2. Cast-Iron Exposed Floor Cleanouts:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Wade; a subsidiary of McWane Inc.
        2) Watts Water Technologies; a Watts company.
        3) Zurn Industries, LLC.

    b. Standard: ASME A112.36.2M.
    c. Size: Same as connected branch.
    d. Options:

        1) Clamping device.

3. Cast-Iron Wall Cleanouts:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Jay R. Smith Mfg Co; a division of Morris Group International.
        2) MIFAB, Inc.
        3) WATTS; A Watts Water Technologies Company.
        4) Wade; a subsidiary of McWane Inc.
        5) Zurn Industries, LLC.

    b. Standard: ASME A112.36.2M. Include wall access.
    c. Size: Same as connected drainage piping.
    d. Body: No-hub, cast-iron soil pipe test tee as required to match connected piping.
    e. Closure Plug:

1) Material: Cast iron.
2) Head: Countersunk or raised.
3) Drilled and threaded for cover attachment screw.
4) Size: Same as, or not more than, one size smaller than cleanout size.

f. Wall-Access Cover Plate: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
g. Wall-Access Frame and Cover: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

4. Cast-Iron Test Tees:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Jay R. Smith Mfg Co; a division of Morris Group International.
2) MIFAB, Inc.
3) Tyler Pipe; a subsidiary of McWane Inc.
4) WATTS; A Watts Water Technologies Company.
5) Zurn Industries, LLC.

b. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
c. Size: Same as connected drainage piping.
d. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
e. Closure Plug: Countersunk or raised head, brass.
f. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains in accordance with roof membrane manufacturer's written installation instructions at low points of roof areas.

1. Install flashing collar or flange of roof drain to maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install downspout boots at grade with top 6 inches above grade. Secure to building wall.

D. Install downspout nozzles at exposed bottom of conductors where they spill onto grade.

E. Install cleanouts in aboveground piping and building drain piping in accordance with the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 ft. for piping NPS 4 and smaller and 100 ft. for larger piping.
4. Locate cleanouts at base of each vertical storm piping conductor.

F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

H. Install test tees in vertical conductors and near floor.

I. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

J. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221414 "Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 INSTALLATION OF FLASHING

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

3.4 CLEANING

A. Clean piping specialties during installation and remove dirt and debris as work progresses.

3.5 PROTECTION

A. Protect piping specialties during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of each day and when work stops.

END OF SECTION 221423

SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Submersible sump pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

2.2 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Double-Seal Sump Pumps:

1. Manufacturer: Zoeller Co.
2. Description: Factory-assembled and tested sump-pump units.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron, semi-open design for clear wastewater handling, and keyed and secured to shaft.
6. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
7. Seals: Mechanical.
8. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
9. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

    a. Motor Housing Fluid: Oil.

10. Guiderail Lifting System:

    a. Powder coated, ductile iron elbows and brackets.
    b. Dual guiderail for greater support and stability while raising and lowering pumps.

11. Controls:

    a. Enclosure: NEMA 4X with lockable latch; wall mounted.
    b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.

e. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical float switch matching control, light and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

12. Control-Interface Features:

a. Remote Alarm Contacts: For remote alarm interface.
b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

1) On-off status of pump.
2) Alarm status.

2.3 SUMP-PUMP CAPACITIES AND CHARACTERISTICS

A. Unit Capacity: 218 gpm.

B. Number of Pumps: Two.

C. Each Pump:

1. Capacity: 109 gpm.
2. Total Dynamic Head: 40 feet.
3. Speed: 3450 rpm.
4. Discharge Size: 2”.
5. Electrical Characteristics:

a. Motor Horsepower: 2 hp.
b. Volts: 460.
c. Phases: 3.
d. Hertz: 60.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of drainage piping connections before sump pump installation.

3.2 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

B. Provide check valves, shutoff valves and unions on each pump discharge piping.

3.3 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test, inspect, and adjust components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Pumps and controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 ADJUSTING

A. Adjust pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 221429

SECTION 223100 - DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Commercial water softeners.
2. Chemicals.
3. Water-testing sets.
4. Underground Bulk Brine Tank

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Water softeners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water softeners.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For water softeners, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Salt for Brine Maker Tanks: Furnish 25 ton load of brine grade rock salt.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended application.

B. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.

C. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softeners that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures of mineral and brine tanks.
    b. Faulty operation of controls.
    c. Deterioration of metals, metal finishes, and other materials beyond normal use.
    d. Attrition loss of resin exceeding 3 percent per year.
    e. Mineral washed out of system during service run or backwashing period.
    f. Effluent turbidity greater and color darker than incoming water.
    g. Fouling of underdrain system, gravel, and resin with turbidity or by dirt, rust, or scale from water softener or soft water, while operating according to manufacturer's written operating instructions.

2. Commercial Water Softeners, Warranty Period: From date of Substantial Completion.

    a. Mineral Tanks: one years.
    b. Brine Tanks: one years.
    c. Control Valve: One year.
    d. Pump: One year

1.11 MAINTENANCE SERVICE

A. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 COMMERCIAL WATER SOFTENERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    1. Basis of Design: Marlo Incorporated Model MHC-3600-8 duplex (NI-120-8). Nancrede Engineering (www.nancrede.com, 317-257-7201)
    2. Aqua Systems, Inc.
    3. Culligan International Company.
    4. Diamond Water Systems, Inc.
    5. Kinetico

B. Description: Factory-assembled, pressure-type water softener.

    1. Standard: Comply with NSF 61 Annex, "Drinking Water System Components - Health Effects."
    2. Configuration: Duplex unit with Two mineral tanks and one brine day tank.
    3. Mounting: On concrete pad.

4. Wetted Components: Suitable for water temperatures from 40 to at least 120 deg F.
5. System Pressure Rating: 125 psig working pressure.

6. Mineral Tanks: Steel, electric welded; pressure-vessel quality.

    a. Seismic Requirements: Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
    b. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
    c. Pressure Rating: 150 psig working pressure, 225 psig testing pressure.
    d. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
    e. Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
    f. Finish: Exterior of tank spray-painted with rust-resistant prime coat, 3-5 mil dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, 10-12 mil dry film thickness. Interior lining must meet NSF 61 certification.
    g. Upper Distribution System: Single, point baffle type, fabricated from schedule 10, 304 stainless-steel pipe and fittings.
    h. Lower Distribution System: The lower distributor system shall be constructed of 304 stainless steel with headers and slotted full flow non-clogging laterals. Basket strainers are not acceptable. A subfill of 1/8" x 1/16" washed gravel will be included.

7. Controls: Automatic; factory wired and factory mounted on unit.
    a. A NEMA 4X rated, factory mounted and wired electrical enclosure with all timing and sequencing controls for each softener shall be manufactured and provided by the same vendor providing the water treatment hardware.
    b. The controls shall include:
        1) An automatic egeneration timer having the capability of providing site adjustable regeneration steps of backwash, brine injection, brine displacement, flush and return to service.
        2) Indicator lights on the controller shall display the current status of the system.
        3) Adjustable duration of various regeneration steps.
        4) Push-button start and complete manual operation.
        5) Electric time clock and switch for automatic operation except for manual return to service.
        6) Includes means of manual operation of pilot-control valve if power fails.
    c. An electrical junction box will be provided on each softener for connection of butterfly valves.
    d. Basis of Design: Allen-Bradley Micrologix 1400 controller with PanelView 800-7 Series operator interface.

8. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

    a. Slow opening and closing, nonslam operation.
    b. Epoxy coated cast iron bodies buna-N diaphragms, and stainless-steel internal parts.
    c. Isolated, dissimilar metals within valve.
    d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
    e. Sampling cocks for soft water.
    f. Special tools are not required for service.
    g. Valves shall include position switches to interface with PLC.
    h. In the event of a power loss, valves will hold their position.

9. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressure; does not require field adjustments.

    a. Demand-Initiated Control: Each multiple mineral-tank unit is equipped with automatic-reset-head water meter, in common outlet header, that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons and divert flow to other tanks. Automatically repeats with other tanks. Electrical lockout prevents simultaneous regeneration of more than one tank.

10. Brine Tank: Combination measuring and wet-salt storing system.

    a. Tank and Cover Material: Fiberglass, 3/16 inch thick; or molded PE, 3/8 inch thick.
    b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawal and freshwater refill.
    c. Size: Large enough for at least four regenerations at full salting.

11. Factory-Installed Accessories:

    a. Piping, valves, tubing, and drains.
    b. Sampling cocks.
    c. Main-operating-valve position indicators.
    d. Water meters.

C. Capacities and Characteristics:

1. Water Analysis:

    a. Hardness: 304.3 ppm.
    b. Iron: 0.14 ppm.
    c. Inlet Water Pressure: 150 psig.
    d. Water Temperature: 50 deg F.

2. Continuous Service Flow Rate: 700 gpm at 15-psig pressure drop.
3. Peak Service Flow Rate: 1000 gpm at 25-psig pressure drop.

4. Water Meter Size: NPS 4 each tank.
5. Manifold Pipe Size: NPS 8 each tank.
6. Backwash-to-Drain Pipe Size: 6 NPS.
7. Water Consumption: 500,000 gal/day.
8. Water Demand: 24 hours/day.
9. Number of Mineral Tanks: Two.
10. Mineral Exchange Capacity: 30,000 grains/cu. ft. per 15 lb of salt.
11. Electrical Characteristics:

    a. Volts: 120.
    b. Phases: 1.
    c. Hertz: 60.

12. Day Tank: 86” DIA x 62” HIGH

2.2 BRINE DAY TANK SYSTEM

A. The brine system shall be a brine measuring type with rotationally-molded polyethylene or FRP construction. It shall be equipped with an ultrasonic level control and electric ball valve for precise control of brine draw and tank refill. Brine shall be transferred and diluted to the softener vessel via a venturi type injector. The injector shall be constructed of PVC with a self-adjusting compensator to convey brine at the correct flow rate regardless variation of water pressure.

B. Brine Day Tank: Combination measuring and wet salt storing system.
   1. Tank and Cover Material: Fiberglass, 3/16 inch thick; or molded PE, 3/8 inch thick.
   2. Brine Valve: level sensor operated, for automatic control of brine withdrawal and freshwater refill.

2.3 BRINE PUMP SKID, SKID MOUNT, PREPIPED AND PREWIRED

A. The saturated pump system will be skid mounted, pre-piped and wired per the following:
   1. The low carbon steel skid to be power tool cleaned to SSPC-SP-3 and primed.
   2. A 3-5 mil finish coat of paint to be applied over the prime coat.

B. System is to communicate with master softener PLC to lockout pump until needed and send alarm signals to the master softener PLC, in the instance of failure.

C. Alt of the skid mounted piping to be Sch 80 PVC with Sch 80 PVC fittings. Some fittings may be threaded. All pressure gauge piping to be sch 40 304 stainless steel.

D. All piping fasteners to be stainless steel.

E. A 2" PVC basket strainer to be provided on the suction side of the brine pump skid.

F. Brine Pumps provided per the following:

1. Qty Required: Two (2) – 2 X 100%
2. Pump Type: Magnetic Drive Centrifugal
3. Pump Material: Polypropylene
4. Performance: 25 gpm at 70' TDH
5. Suction Type: Flooded
6. Motor: 2 HP 460V 60HZ 3PH TEFC

G. CONTROL SYSTEMS
1. All pump motors to be provided with a NEMA 4X motor control center. All of the required motor starters to be provided.
2. All exterior high voltage wiring to be contained in EMT steel conduit. Watertight flexible conduit may be used on runs 3' or shorter.

H. TESTING
1. The complete pump skid will have a full hydro-test before shipping at 150 psig for 2 hours to ensure the skid to be leak free before shipping.

2.4 LOW FLOW RECIRCULATION SYSTEM

A. Recirculation System: The softener shall include a recirculation pump, piping and valves to maintain a minimum flow through softener even when the facility flow is low.

2.5 CHEMICALS

A. Mineral: High-capacity, sulfonated-polystyrene, ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.

1. Exchange Capacity: 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.

2. Rated Salt Capacity: Not less than 3500 grains of total hardness exchange per pound of salt.

2.6 BULK BRINE SYSTEM

A. Brine Tank for underground installation, double wall, horizontal, cylindrical, fiberglass tank, compatible with salt, salt brine, and potable water products. All components shall meet NSF61 requirements and the briner shall bear the NSF61 label.

B. Double Walled, Underground Brine Tank, FRP material.
1. Basis of Design: Nancreed Engineering Company, Inc. 800-820-9021 Model NEDW1026 (13,000 gallon double walled brine tank)
2. Approved Equal

C. Loading Conditions
1. The unit is to be designed for use with rock, solar or evaporated salt.

2. Surface Loads – brine tank shall withstand surface H-20 axle loads when properly installed according to manufacturer's guidelines.
3. Tank shall be capable of being buried in ground with 7' of overburden over the top of the tank, the hole fully flooded, and maintain a safety factor of 5:1 against general buckling
4. The brine tank shall support accessory equipment – such as manways, manway extensions, collar/ risers, FRP inlet/outlet piping, baffle wall, anti-vortex plates and pump platforms when installed according to tank manufacturer's guidelines
5. Buried tanks shall be manufactured with integral trapezoidal ribs for structural integrity

D. Product Storage
1. Tank shall be capable of handling liquids with specific gravity up to 1.3
2. Tank shall be vented to atmospheric utilizing a dust bag to capture salt dust while having sufficient surface area and fabric design to prevent over-pressurization of the briner
3. Tank shall be capable of handling salt brine at ambient temperature

E. Interstitial Space for Double-Wall Application
1. Tank shall have a space between the primary and secondary walls to allow for the free flow and containment of leaked product from the primary tank. The space also allows the insertion of a monitoring device through a monitoring fitting.
2. Each interstitial space monitor fitting shall consist of a 4" NPT fitting.
3. An interstitial leak detector shall be provided for the underground tank.

F. Standard features
1. Manway Opening
   a. Provide at least one 30" flanged manway opening with extension to grade with watertight cover
   b. When an internal ladder is provided, a section of ladder shall be integral to the extension

G. Standard Connections
1. Water Inlet: 2" flange / 1" coupling with 1" interior SS water distribution header system
2. Brine Outlet: 3" flange with 2" internal collection plenum and check valve
3. Level Sensor: 3" flange with internal stilling well and support
4. Vent: 8" flange and flanged extension to grade + dust bag + SS clamps
5. Salt Inlet: 6" flange x 4" SS header + 4" SS flanged extension to grade + quick connect and cap – and with an internal SS distribution header (for even salt distribution throughout vessel)

H. Fitting Enclosures
1. (2) 42" diameter x 36" tall (other heights available depending on burial depth) enclosures shall be provided for the connections as identified in section B above
2. Enclosure shall be cut to length and bonded in the field - by others

I. Lifting Lugs

1. All Tanks shall have lifting lugs that are capable of withstanding weight of tank with a safety factor of at least 2:1

J. Water Level Control System
1. The Water Level Control System shall consist of a submersible pressure transmitter, controller with LED readout, relays, and 4-20mA repeater, NEMA 4X enclosure, and solenoid valve.

K. Salt dust mitigation System
1. A water spray system shall be included to provide salt dust abatement.

L. Salt Level Indication System
1. The Salt Level Indication System shall consist of a Brine Concentration Monitoring System with installation TEE, submersible torroidal conductivity sensor with 4-20mA signal, controller with LED readout, relays, and 4-20mA repeater

M. Ladder
1. FRP ladder(s) shall be NSF Listed under ANSI/NSF Standard 61 as supplied by tank manufacturer
2. Manway extension to grade shall include a ladder section

N. Dust Bag Housing
1. Protect the dust bag from the elements and the briner from over-pressurization

O. NSF 61/ANSI Labeled
1. Certified to NSF 61/ANSI (for potable water)

P. Gravel Bed
1. The brine collection plenum shall be covered by 7” of 1/4” – 1/2” and then 5” of 1/8” – 1/4” NSF/AWWA quartz stone to serve as a filtration layer (as recommended by Morton Salt)

Q. Traffic Covers - 3
1. (3) H25 rated fiberglass traffic covers for grade access to fitting housings and manway

R. Complete Anchorage System
1. The Complete Anchorage System shall consist of precast concrete deadmen, fiberglass straps, and turnbuckles

2.7 WATER-TESTING SETS

A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.8 SOURCE QUALITY CONTROL

A. Hydrostatically test mineral tanks before shipment to a minimum of one and one-half times the pressure rating.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WATER SOFTENER INSTALLATION

A. Equipment Mounting:

1. Install commercial water softeners on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure.

C. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.

D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

E. Install water-testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to equipment, allow space for service and maintenance of equipment.

C. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.

1. Metal general-duty valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 " and Section 220523.15 "Gate Valves for Plumbing Piping."

2. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

D. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gages are specified in Section 220519 "Meters and Gages for Plumbing Piping."

1. Exception: Water softeners with factory-installed pressure gages at locations indicated.

E. Install valved bypass in water piping around water softeners.

1. Metal general-duty valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Water piping is specified in Section 221116 "Domestic Water Piping."

F. Install drains as indirect wastes to spill into open drains or over floor drains.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Water softeners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Contractor to provide 25 tons of softener grade rock salt to brine maker tank. Start-up services will add water to brine maker tank and ensure brine maker system is operational.

C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples) and prepare certified test reports for required water performance characteristics. Comply with the following:

1. ASTM D 1068, "Test Methods for Iron in Water."
2. ASTM D 1126, "Test Method for Hardness in Water."
3. ASTM D 1129, "Terminology Relating to Water."
4. ASTM D 3370, "Practices for Sampling Water from Closed Conduits."

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water softeners.

END OF SECTION 223100

SECTION 223300 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Commercial, electric, storage, domestic-water heaters.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

   1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For commercial domestic-water heaters, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of commercial, electric, domestic-water heater, from manufacturer.

C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures including storage tank and supports.
    b. Faulty operation of controls.
    c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

    a. Commercial, Electric, Storage, Domestic-Water Heaters:

        1) Storage Tank: Five years.
        2) Controls and Other Components: Three years.

    b. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A. O. Smith Corporation.
    b. Bock Water Heaters, Inc. – Basis of Design
    c. Bradford White Corporation.
    d. Lochinvar, LLC.
    e. Rheem Manufacturing Company.

2. Standard: UL 1453.
3. Storage-Tank Construction: ASME-code, steel vertical arrangement.

    a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

        1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
        2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

    b. Pressure Rating: 150 psig.
    c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

4. Factory-Installed Storage-Tank Appurtenances:

    a. Anode Rod: Replaceable magnesium.
    b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
    c. Insulation: Comply with ASHRAE/IESNA 90.1.
    d. Jacket: Steel with enameled finish.
    e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
    f. Temperature Control: Adjustable thermostat.
    g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
    h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

5. Special Requirements: NSF 5 construction.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A. O. Smith Corporation.
    b. AMTROL, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. State Industries.
    e. TACO Comfort Solutions, Inc.

2. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction:

    a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
    b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
    c. Air-Charging Valve: Factory installed.

4. Capacity and Characteristics:

    a. Working-Pressure Rating: 150 psig.

b. See schedule on P series drawings.

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Manifold Kits: Domestic-water heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and calibrated balancing valves to provide balanced flow through each domestic-water heater.

1. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."

F. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig-maximum outlet pressure unless otherwise indicated.

G. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

H. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

I. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

J. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

K. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 18 inches above the floor.

L. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."

1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Install electric, domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping,"

Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

C. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

G. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

H. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

I. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping," and comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

J. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.

K. Fill electric, domestic-water heaters with water.

L. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, electric, domestic-water heaters.

END OF SECTION 223300

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Water closets.
2. Flushometer valves.
3. Toilet seats.
4. Supports.

1.3 DEFINITIONS

A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.

B. Remote Water Closet: Located more than 30 feet from other drain line connections or fixture and where less than 1.5 drainage fixture units are upstream of the drain line connection.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than one of each type.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED WATER CLOSETS

A. Water Closets: Wall mounted, top spud.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. Kohler Co.
c. Sloan Valve Company.
d. Zurn Industries, LLC.

2. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: Standard.
f. Rim Contour: Elongated.
g. Water Consumption: 1.28 gal. per flush.
h. Spud Size and Location: NPS 1-1/2; top.

3. Support: Water closet carrier.
4. Water-Closet Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

2.2 FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Delany Products.
b. Sloan Valve Company.
c. Zurn Industries, LLC.

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig.
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed.
9. Consumption: 1.28 gal. per flush.
10. Minimum Inlet: NPS 1.
11. Minimum Outlet: NPS 1-1/4.

2.3 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Bemis Manufacturing Company.
    b. Church Seats; Bemis Manufacturing Company.
    c. Kohler Co.
    d. Zurn Industries, LLC.

2. Standard: IAPMO/ANSI Z124.5.
3. Material: Plastic.
4. Type: Commercial (Standard).
5. Shape: Elongated rim, open front.
6. Hinge: Self-sustaining, check.
7. Hinge Material: Noncorroding metal.
8. Seat Cover: Not required.
9. Color: White.

2.4 SUPPORTS

A. Water Closet Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Jay R. Smith Mfg Co; a division of Morris Group International.
    b. MIFAB, Inc.
    c. Sioux Chief Mfg. Co., Inc.
    d. Zurn Industries, LLC.

2. Standard: ASME A112.6.1M.
3. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.
2. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:
1. Use carrier supports with waste-fitting assembly and seal.
2. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations that are easy for people with disabilities to reach.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.

3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224213.16 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Urinals.
2. Flushometer valves.
3. Supports.

B. Related Requirements:

1. Section 224600 "Security Plumbing Fixtures" for security urinals.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for urinals.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than one of each type.
2. Waterless Urinal Trap-Seal Cartridges: Equal to 200 percent of amount of each type installed, but no fewer than 12 of each type.
3. Waterless Urinal Trap-Seal Liquid: Equal to 1 gal. for each urinal installed.

PART 2 - PRODUCTS

2.1 HYBRID WATERLESS URINALS

A. Urinals: Wall hung, back outlet, waterless, vitreous china, designed for liquid-trap-seal operation.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Falcon Waterfree Technologies.
   b. Sloan Valve Company. – basis of design
   c. Waterless Co.
   d. Zurn Industries, LLC.

2. Fixture:

   a. Standard: ASME A112.19.2/CSA B45.1, except without water supply.
   b. Trap-Seal Method: Proprietary cartridge with liquid seal.
   c. Outlet Size and Location: NPS 2 flange; back.
   d. Trap-Sealing Liquid: Proprietary.
   e. Color: White.

3. Waste Fitting:

   a. Standard: ASME A112.18.2/CSA B125.2 for transition coupling, trap, and waste pipe.
   b. Size: NPS 2.Coordinate "Support" Subparagraph below with "Supports" Article.

4. Rinse Operation: 1 gallon per 72 hours, water free normal operation

5. Support: Type I Urinal Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
6. Urinal Mounting Height: Handicapped/elderly according to ICC A117.1.

2.2 SUPPORTS

A. Type I Urinal Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Jay R. Smith Mfg Co; a division of Morris Group International.
    b. Josam Company.
    c. MIFAB, Inc.
    d. Sioux Chief Mfg. Co., Inc.
    e. Zurn Industries, LLC.

2. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.

B. Examine walls and floors for suitable conditions where urinals will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.
5. Install trap-seal liquid in waterless urinals.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
4. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed urinals and fittings.

C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

SECTION 224216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vitreous-china, wall-mounted lavatories.
2. Manually operated lavatory faucets.
3. Supply fittings.
4. Waste fittings.
5. Lavatory supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Servicing and adjustments of automatic faucets.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

A. Lavatory - Ledge Back, Rectangular, Vitreous China, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. Kohler Co.
c. Sloan Valve Company.

2. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: For wall hanging.
c. Nominal Size: Rectangular, 20 by 18 inches.
d. Faucet-Hole Punching: Three holes, 4-inch centers.
e. Faucet-Hole Location: Top.
f. Color: White.
g. Mounting Material: Chair carrier.

3. Faucet: See schedule on P series drawings.
4. Support: Type II, concealed-arm lavatory carrier..
5. Lavatory Mounting Height: Handicapped/elderly in accordance with ICC A117.1.

2.2 MANUALLY OPERATED LAVATORY FAUCETS

A. Lavatory faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61/NSF 372, or be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI) accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. Lavatory Faucets - Manual Type: Single-Control Mixing, Commercial,:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. American Standard.
    b. Chicago Faucets; Geberit Group.
    c. Kohler Co.
    d. T&S Brass and Bronze Works, Inc.
    e. Zurn Industries, LLC.

2. Standard: ASME A112.18.1/CSA B125.1. WaterSense Certified.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
4. Body Type: Centerset.
5. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
6. Finish: Polished chrome plate.
7. Maximum Flow Rate: 0.35 gpm.
8. Mounting Type: Deck, exposed.
9. Valve Handle(s): Single lever.
10. Spout: Rigid type.
11. Spout Outlet: Laminar flow.
12. Operation: Compression, manual.

2.3 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type, or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

F. Risers:

1. NPS 3/8.
2. Chrome-plated, rigid-copper-pipe and brass straight or offset tailpieces riser.

2.4 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2 by NPS 1-1/4.
2. Material:

a. Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated, brass or steel wall flange.
b. Stainless steel, two-piece trap and swivel elbow with 0.012-inch thick stainless steel tube to wall, and stainless steel wall flange.

2.5 LAVATORY SUPPORTS

A. Lavatory Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg Co; a division of Morris Group International.
b. MIFAB, Inc.
c. Sioux Chief Mfg. Co., Inc.
d. Zurn Industries, LLC.

2. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.

B. Examine counters and walls for suitable conditions where lavatories will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install lavatories level and plumb in accordance with roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, in accordance with ICC A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 PIPING CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.6 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 224216.16 - COMMERCIAL SINKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Service basins.
2. Utility sinks.
3. Sink faucets.
4. Laminar-flow, faucet-spout outlets.
5. Supports.
6. Supply fittings.
7. Waste fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
2. Include rated capacities, operating characteristics and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sinks to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 SERVICE BASINS

A. Service Basins: Plastic, floor mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. FIAT Products, LLC.
b. ProFlo; a Ferguson Enterprises, Inc. brand.
c. Zurn Industries, LLC.

2. Fixture:

a. Standard: IAPMO/ANSI Z124.6.
b. Material: Cast polymer.
c. Nominal Size: 24 by 24 by 10 inches.
d. Rim Guard: On all top surfaces.
e. Color: Not applicable.
f. Drain: Grid with NPS 3 outlet.

3. Mounting: On floor and flush to wall.
4. Faucet: See schedule on P series drawings.

2.2 UTILITY SINKS

A. Utility Sinks: Enameled, cast iron, trap standard mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard.
b. Kohler Co.
c. Zurn Industries, LLC.

2. Fixture:

   a. Standard: ASME A112.19.1/CSA B45.2.
   b. Type: Service sink with back.
   c. Back: Two faucet holes.
   d. Nominal Size: 24 by 20 inches.
   e. Color: White.
   f. Mounting: NPS 3 P-trap standard with grid strainer inlet, cleanout, and floor flange.
   g. Rim Guard: On front and sides.

3. Faucet: See schedule on P series drawings.

2.3 SINK FAUCETS

A. NSF Standard: Comply with NSF 372 for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Manual type, two-lever-handle mixing valve.

1. Commercial, Solid-Brass Faucets.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) Chicago Faucets; Geberit Company.
      2) Delta Faucet Company.
      3) Moen Incorporated.
      4) T&S Brass and Bronze Works, Inc.
      5) Zurn Industries, LLC.

2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
4. Body Type: Centerset.
5. Body Material: Commercial, solid brass.
6. Finish: Chrome plated.
7. Maximum Flow Rate: 2.2 gpm.
8. Handle(s): Lever.
9. Mounting Type: Back/wall, exposed.
10. Spout Type: Rigid, solid brass.
11. Vacuum Breaker: Required for hose outlet.
12. Spout Outlet: Hose thread according to ASME B1.20.7.

2.4 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

A. NSF Standard: Comply with NSF 372 for faucet-spout-outlet materials that will be in contact with potable water.

B. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.5 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 372 for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

F. Risers:

1. NPS 1/2.
2. ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

2.6 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2.
2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated brass or steel wall flange.
3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless-steel tube to wall; and stainless-steel wall flange.

2.7 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.

B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Set floor-mounted sinks in leveling bed of cement grout.

D. Install water-supply piping with stop on each supply to each sink faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

G. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

SECTION 224223 - COMMERCIAL SHOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Individual shower receptors.
2. Shower faucets.
3. Grout.

B. Related Requirements:
1. Section 224500 "Emergency Plumbing Fixtures" for emergency showers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for showers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For shower faucets to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.

2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 INDIVIDUAL SHOWERS

A. Individual PMMA Showers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aquarius Bathware; a Praxis Company.
b. Aquatic Industries, Inc.
c. Kohler Co.
d. LASCO Bathware.
e. MAAX.

2. General: PMMA shower enclosure with faucet and receptor and appurtenances.
3. Standard: ANSI Z124.1.2.
4. Type: One-piece unit without top.
5. Style: Handicapped/wheelchair.
6. Faucet: See schedule on P series drawings.
7. Nominal Size and Shape: 38 by 36 to 38 inches rectangular.
8. Color: White.
9. Bathing Surface: Slip resistant according to ASTM F 462.
10. Outlet: Drain with NPS 2 outlet.
11. Shower Rod and Curtain: Required.
12. Grab Bar: ASTM F 446, mounted on support area back wall.
13. Drain: Grid, NPS 2.

2.2 SHOWER FAUCETS

A. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for shower materials that will be in contact with potable water.

B. Shower Faucets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. American Standard.
b. Chicago Faucets; Geberit Company.
c. Kohler Co.
d. Lawler Manufacturing Company, Inc.
e. Moen Incorporated.
f. Sloan Valve Company.

g. Zurn Industries, LLC.

2. Description: Single-handle, pressure-balance mixing valve with hot- and cold-water indicators; check stops; and shower head.
3. Faucet:

a. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
b. Body Material: Solid brass.
c. Finish: Polished chrome plate.
d. Shower-Arm, Flow-Control Fitting: 1.5 gpm.
e. EPA WaterSense: Required.
f. Mounting: Exposed.
g. Operation: Single-handle, twist or rotate control.
h. Antiscald Device: Integral with mixing valve.
i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

4. Supply Connections: NPS 1/2.
5. Shower Head:

a. Standard: ASME A112.18.1/CSA B125.1.
b. Type: With or without ball joint, but with arm and flange.
c. Shower Head Material: Metallic with chrome-plated finish.
d. Integral Volume Control: Not required.
e. Shower-Arm, Flow-Control Fitting: 1.5 gpm.
f. Temperature Indicator: Integral with faucet.

2.3 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before shower installation.

B. Examine walls and floors for suitable conditions where showers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble shower components according to manufacturers' written instructions.

B. Install showers level and plumb according to roughing-in drawings.

C. Install water-supply piping with stop on each supply to each shower faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with shower. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

D. Install shower flow-control fittings with specified maximum flow rates in shower arms.

E. Set shower receptors in leveling bed of cement grout.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheons requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between showers and floors and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with traps and soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust showers and controls. Replace damaged and malfunctioning showers, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of showers, inspect and repair damaged finishes.

B. Clean showers, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed fixtures and fittings.

D. Do not allow use of showers for temporary facilities unless approved in writing by Owner.

END OF SECTION 224223

SECTION 224500 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Combination units.
2. Supplemental equipment.
3. Water-tempering equipment.

1.2 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Portable, Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid supply.

D. Tepid: Between 60 and 100 deg F.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings:

1. Plans, elevations, sections, and mounting details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Submittals:

1. Field quality-control reports.

B. Emergency fixture third-party certification documentation.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ANSI/ISEA Z358.1 for emergency plumbing fixtures including third-party certification of fixtures.

B. Comply with ASSE 1071 for temperature-actuated mixing valves for plumbed emergency fixtures.

C. Comply with ASME A112.18.1/CSA B125.1 for water-supply fittings.

D. Comply with ASME A112.18.2/CSA B125.2 for plumbing waste fittings.

E. Comply with NSF 61 and NSF 372 for fixture materials that will be in contact with potable water.

F. Comply with requirements in ICC A117.1 for plumbing fixtures for people with disabilities.

2.2 COMBINATION UNITS

A. Combination Units - Emergency Shower with Eye/Face Wash, Standard, Plumbed:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Acorn Safety; a Division of Morris Group International.
   b. Bradley Corporation.
   c. Guardian Equipment Co.
   d. Haws Corporation.

2. Source Limitations: Obtain combination units, emergency shower with eye/face wash, standard, plumbed, from single manufacturer.
3. Piping:

   a. Material: ABS .

b. Unit Supply: NPS 1-1/4 minimum.
c. Unit Drain: Outlet at back or side near bottom.

4. Shower:

a. Capacity: Not less than 20 gpm for at least 15 minutes.
b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Pull rod.
d. Shower Head: 8-inch- minimum diameter, chrome-plated brass or stainless steel or plastic.
e. Mounting: Pedestal.

5. Eye/Face Wash Unit:

a. Capacity: Not less than 3.0 gpm for at least 15 minutes.
b. Supply Piping: NPS 1/2 with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
e. Receptor: Plastic or stainless-steel bowl.
f. Mounting: Attached shower pedestal.

B. Combination Units - Emergency Shower with Eye/Face Wash, Freeze Protected, Plumbed: .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Acorn Safety; a Division of Morris Group International.
b. Bradley Corporation.
c. Guardian Equipment Co.
d. Haws Corporation.

2. Source Limitations: Obtain combination units, emergency shower with eye/face wash, freeze protected, plumbed, from single manufacturer.
3. Piping: Galvanized steel.

a. Unit Supply: NPS 1-1/4 minimum from bottom.

4. Heating System: Electric, 240 V ac; insulation enclosed in a protective jacket with thermometer.

a. Heating Capacity: 10 deg F minimum above ambient temperature.
b. Design Ambient Temperature: minus 20 deg F.

5. Shower:

a. Shower Capacity: Not less than 20 gpm for at least 15 minutes.
b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.

c. Control-Valve Actuator: Pull rod.
d. Shower Head: 8-inch- minimum diameter, stainless steel.
e. Mounting: Pedestal.

6. Eye/Face Wash Unit:

a. Capacity: Not less than 3 gpm for at least 15 minutes.
b. Control-Valve Actuator: Paddle.

2.3 WATER-TEMPERING EQUIPMENT

A. Water-Tempering Equipment - Hot and Cold Water:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Acorn Safety; a Division of Morris Group International.
b. Guardian Equipment Co.
c. Haws Corporation.
d. Lawler Manufacturing Company, Inc.

2. Source Limitations: Obtain water-tempering equipment, hot and cold water, from single manufacturer.
3. Description: Factory-fabricated equipment with thermostatic mixing valve.

a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
b. Supply Connections: For hot and cold water.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATON OF EMERGENCY PLUMBING FIXTURE

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

1. Exceptions:

a. Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
b. Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

F. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

H. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

I. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

K. Fill self-contained fixtures with flushing fluid.

3.3 PIPING CONNECTIONS

A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

C. Connect cold water and electrical power to electric heating water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."

D. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

E. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

F. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.6 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 ADJUSTING

A. Operate and adjust emergency plumbing fixtures and controls. Replace damaged and malfunctioning fixtures and controls.

B. Adjust or replace fixture flow regulators for proper flow.

C. Adjust equipment temperature settings.

3.8 CLEANING AND PROTECTION

A. Clean emergency plumbing fixtures with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed emergency plumbing fixtures and fittings.

C. Do not allow use of emergency plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224500

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 1500 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with

indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F .

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T .

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by VFC controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Provide motor shaft grounding rings to protect bearings.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.
   Electronically commutated motors (ECM)

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 ECM MOTORS

A. Motors larger than 1/20 hp may be ECM type specifically designed to suit starting torque and requirements of specific motor application:

B. Brushless permanent magnet DC motor with electronic control board to convert AC power to DC power and control motor speed and torque.

C. Multispeed Motors: Adjustable constant speed or Variable speed to match application requirements.

D. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Packless expansion joints.
   2. Alignment guides and anchors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Provide products suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Provide products and installations that will accommodate maximum axial movement as scheduled or indicated on Drawings.

2.2 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints: FHEJ-01.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Flex-Hose Co., Inc.
   b. Flexicraft Industries.
   c. Metraflex Company (The).

2. Source Limitations: Obtain flexible-hose packless expansion joints from single manufacturer.
3. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
4. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
5. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

   a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.

6. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 : Copper-alloy fittings with threadedend connections.

   a. Stainless steel hoses and single-braid, stainless steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

7. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.

   a. Stainless steel hoses and single-braid, stainless steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.

8. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon steel fittings with flanged end connections.
   a. Stainless steel hoses and double-braid, stainless steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.

9. Expansion Joints for Steel Piping NPS 8 and Larger: Carbon steel fittings with flanged end connections.
   a. Stainless steel hoses and double-braid, stainless steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides: AG-01.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Advanced Thermal Systems, Inc.
   b. Hyspan Precision Products, Inc.
   c. Metraflex Company (The).

2. Source Limitations: Obtain alignment guides from single manufacturer.
3. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

   a. Stud: Threaded, zinc-coated carbon steel.
   b. Expansion Plug: Zinc-coated carbon steel.
   c. Washer and Nut: Zinc-coated carbon steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

   a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
   c. Washer and Nut: Zinc-coated carbon steel.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS - GENERAL

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.2 INSTALLATION OF PACKLESS EXPANSION JOINTS

A. Install metal-bellows packless expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

B. Install rubber packless expansion joints according to FSA-PSJ-703.

3.3 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9.
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-58, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
3. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves without waterstop.
2. Sleeves with waterstop.
3. Stack-sleeve fittings.
4. Sleeve-seal systems.
5. Grout.
6. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For sealants, indicating VOC content.
2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES WITHOUT WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.

C. Steel Sheet Sleeves: ASTM A653/A653M, 0.0239-inch minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 SLEEVES WITH WATERSTOP

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: Manufactured steel, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.

2.3 STACK-SLEEVE FITTINGS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: Manufactured, [**Dura-coated or Duco-coated**] [**galvanized**] cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.4 SLEEVE-SEAL SYSTEMS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Designed to form a hydrostatic seal of 20 psig.
2. Sealing Elements: [**EPDM-rubber**] [**High-temperature-silicone**] [**Nitrile (Buna N)**] interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
3. Pressure Plates: [**Carbon steel**] [**Composite plastic**] [**Stainless steel**] [**Stainless steel, Type 316**].
4. Connecting Bolts and Nuts: [**Carbon steel, with ASTM B633 coating**] [**Stainless steel**] [**Stainless steel, Type 316,**] of length required to secure pressure plates to sealing elements.

2.5 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000 psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES - GENERAL

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 INSTALLATION OF SLEEVES WITH WATERSTOP

A. Install sleeve with waterstop as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal space around outside of sleeves.

3.3 INSTALLATION OF STACK-SLEEVE FITTINGS

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.4 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
2. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.6 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above and below Grade:

    a. Sleeves with waterstops.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

2. Concrete Slabs-on-Grade:

    a. Sleeves with waterstops.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs above Grade:

    a. Sleeves with waterstops or stack-sleeve fittings.

4. Interior Walls and Partitions:

    a. Sleeves without waterstops.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. Mid-America Fittings, LLC; A Midland Industries Company.

2.2 ESCUTCHEONS

A. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece stamped steel or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
b. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 230518

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Light-activated thermometers.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.
8. Test-plug kits.

B. Related Sections:

1. Section 231123 "Facility Natural-Gas Piping" for gas meters.
2. Section 232216 "Steam and Condensate Piping Specialties" for steam and condensate meters.
3. 230923.13 “Energy Meters” for hydronic energy meters
4. 230923.14 “Flow Instruments” for hydronic flow meters

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
4. Miljoco Corporation.
5. Nanmac Corporation.
6. Noshok.
7. Palmer Wahl Instrumentation Group.
8. REOTEMP Instrument Corporation.
9. Tel-Tru Manufacturing Company.
10. Trerice, H. O. Co.
11. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
12. Weiss Instruments, Inc.
13. WIKA Instrument Corporation - USA.
14. Winters Instruments - U.S.

B. Standard: ASME B40.200.

C. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.

D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.

E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.

F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1 percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ashcroft Inc.
   b. Marsh Bellofram.
   c. Miljoco Corporation.
   d. Palmer Wahl Instrumentation Group.
   e. REOTEMP Instrument Corporation.
   f. Trerice, H. O. Co.
   g. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: .
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus 1 percent of scale range.
13.

2.3 LIGHT-ACTIVATED THERMOMETERS

A. Direct-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

   a. Trerice, H. O. Co.
   b. Weiss Instruments, Inc.
   c. WIKA Instrument Corporation - USA.

d. Winters Instruments - U.S.

2. Case: Metal ; 9-inch nominal size unless otherwise indicated.
3. Scale(s): Deg F and deg C.
4. Case Form: Adjustable angle .
5. Connector: 1-1/4 inches , with ASME B1.1 screw threads.
6. Stem: Aluminum and of length to suit installation.

   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.

7. Display: Digital.
8. Accuracy: Plus or minus .5 deg F.

B. Remote-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

   a. Miljoco Corporation.
   b. Weiss Instruments, Inc.
   c. Winters Instruments - U.S.

2. Case: Plastic, for wall mounting.
3. Scale(s): Deg F and deg C.
4. Sensor: Bulb and thermister wire.

   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.

5. Display: Digital.
6. Accuracy: Plus or minus .5 deg F.

2.4 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.5 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR .
4. Material for Use with Steel Piping: CRES .

5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.6 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. AMETEK, Inc.; U.S. Gauge.Ashcroft Inc.
   b. Trerice, H. O. Co.
   c. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   d. Weiss Instruments, Inc.
   e. WIKA Instrument Corporation - USA.
   f. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel ; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 , ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi .
8. Pointer: Dark-colored metal.
9. Window: Glass .
10. Ring: Metal .
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.7 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 , ASME B1.20.1 pipe threads and piston -type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass or stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2 , ASME B1.20.1 pipe threads.

2.8 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trerice, H. O. Co.
2. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
3. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F .

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.9 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

1. Trerice, H. O. Co.
2. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
3. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F .

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F .

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig .

F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install valve and snubber in piping for each pressure gage for fluids (except steam).

I. Install valve and syphon fitting in piping for each pressure gage for steam.

J. Install test plugs in piping tees.

K. Install flow indicators in piping systems in accessible positions for easy viewing.

L. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic coil.
2. Inlet and outlet of each hydronic boiler.
3. Evaporator and condenser inlets and outlets of each chiller.
4. Inlets and outlets of each heat exchanger.
5. Inlets and outlet of each mixing valve
6. Inlet and outlet of each hydronic coil in air-handling units.
7. In each air handler outside air, return air, and supply air duct.
8. Before and after piping junctions as indicated on drawings.

Adjacent to each temperature transmitter.Where indicated on drawings and plans

M. Install pressure gages in the following locations:

1. Inlet and discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller evaporator and condenser connection.
3. Inlet and outlet of each plate and frame heat exchanger.
4. Inlet and outlet of each mixing valve.

5. Suction and discharge of each pump.
6. At each hydronic expansion tank.
7. At each makeup water station.
8. At inlet and outlet of each strainer or filter (both hydronic and air). Pressure gauges for strainers and filters may be differential type.
9. Inlet and outlet of each hydronic coil.
10. Where indicated on the drawings and plans

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic boiler are to be the following:
1.
2. **Direct** mounted, light-activated type.
3.

B. Thermometers at inlets and outlets of each chiller are to be the following:
1.
2. **Direct** mounted, light-activated type.
3.

C. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems are to be the following:
1. Direct-mounted, light-activated type.
2. Test plug with EPDM self-sealing rubber inserts.

D. Thermometers at inlets and outlets of each hydronic heat exchanger are to be the following:
1.
2. **Direct**]mounted, light-activated type.
3.

E. Thermometers at outside-, return-, supply-, and mixed-air ducts are to be the following:
1. Direct-mounted, light-activated type.

F. Thermometer stems are to be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping:
   1. 0 to 100 deg F.

B. Scale Range for Condenser-Water Piping:
   1. 0 to 150 deg F.

C. Scale Range for Heating, Hot-Water Piping:

   1. 0 to150 deg F.
   2. 30 to 240 deg F.

D. Scale Range for Steam and Steam-Condensate Piping:
   1. 30 to 240 deg F.
   2. 50 to 400 deg F.

E. Scale Range for Air Ducts:

   1. Minus 40 to plus 110 deg F.
   2. Minus 40 to plus 160 deg F.
   3. 0 to 100 deg F.
   4. 0 to 150 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be the following:

   1. Sealed, direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:

   1. Liquid-filled, direct-mounted, metal case.

C. Pressure gages at suction and discharge of each pump shall be one of the following:

   1. Liquid-filled, direct -mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 200 psi.

B. Scale Range for Condenser-Water Piping: 0 to 150 psi

C. Scale Range for Heating, Hot-Water Piping: 0 to 200 psi

D. Scale Range for Low Pressure Steam Piping: 0 to 30 psi

E. Scale Range for Medium Pressure Steam Piping: 0 to 150 psi

END OF SECTION 230519

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.
3. Iron, single-flange butterfly valves.
4. Bronze swing check valves.
5. Iron Swing Check valves
6. Iron Globe Center Guided Check Valves
7. Bronze gate valves.
8. Iron gate valves.
9. Bronze globe valves.
10. Lubricated plug valves.
11. Chainwheels.

B. Related Sections:

1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every **5** plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
d. Hammond Valve.
e. Jamesbury; a subsidiary of Metso Automation.
f. Kitz Corporation.
g. Milwaukee Valve Company.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.3 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.4 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 250 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. DeZurik Water Controls.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Red-White Valve Corporation.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 250 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze or nylon coated ductile iron.

2.5 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Single-Flange (Lug-Type), High-Performance Butterfly Valves, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABZ Valve and Controls.
b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
c. Bray Commercial.
d. DeZURIK.
e. Emerson Electric Co., Commercial and Residential Solutions.
f. Flowseal; Crane Energy Flow Solutions.
g. Hammond Valve.
h. Lance Valves.
i. Milwaukee Valve Company.
j. Stockham; a Crane Co. brand.
k. XOMOX; Crane ChemPharma & Energy.

2. Standard: MSS SP-68.
3. CWP Rating: 285 psig at 100 deg F.
4. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
5. Body Material: Carbon or stainless steel.
6. Seat: Reinforced PTFE or metal.

7. Stem: Stainless steel; offset from seat plane.
8. Disc: Type 316 stainless steel.
9. Service: Bidirectional.

2.6 IRON, DOUBLE-FLANGE BUTTERFLY VALVES

A. 250 CWP, Iron, Double-Flange Butterfly Valves with EPDM Seat:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

   a. Conbraco Industries, Inc.; Apollo Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. DeZurik Water Controls.
   e. Hammond Valve.
   f. Kitz Corporation.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Red-White Valve Corporation.
   j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 250 psig.
   c. Body Design: Double flange type; suitable for bidirectional dead-end service at 150 psig pressure without use of downstream flange and rated pressure with downstream flange.
   d. Body Material: ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze or nylon coated ductile iron

2.7 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Hammond Valve.

f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Red-White Valve Corporation.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.
g. Seat: Aluminum Bronze.

B. Iron Swing Check Valves with Metal Seats, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
c. Bray Commercial.
d. Clow Valve Company; a subsidiary of McWane, Inc.
e. Cooper Valves.
f. Crane Fluid Systems; Crane Co.
g. DeZURIK.
h. FNW; Ferguson Enterprises, Inc.
i. GA Industries, Inc.
j. Hammond Valve.
k. Jenkins Valves; a Crane Co. brand.
l. Jomar Valve.
m. KITZ Corporation.
n. Kennedy Valve Company; a division of McWane, Inc.
o. Lance Valves.
p. Milwaukee Valve Company.
q. Powell Valves.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 20, CWP Rating: 200 psig at 100°F.
c. Temperature -20 to 180 °F.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.

h. Gasket: Asbestos free.

C. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crispin Valve.
b. DFT Inc.
c. Flomatic Valves; Flomatic Corporation.
d. GA Industries, Inc.
e. KITZ Corporation.
f. Metraflex Company (The).
g. Milwaukee Valve Company.
h. Stayflow
i. Val-Matic Valve & Manufacturing Corp.
j. WATTS; A Watts Water Technologies Company.

2. Description:

a. Standard: MSS SP-150.
b. NPS 2-1/2 to NPS 24, CWP Rating: 250 psig at 100°F.
c. Temperature range -460 to 450°F
d. Body Material: ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.

2.8 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Red-White Valve Corporation.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron**, bronze, or aluminum**.

B. Class 125, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron**, bronze, or aluminum**.

C. Class 150, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. Hammond Valve.
b. Kitz Corporation.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Powell Valves.
f. Red-White Valve Corporation.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

D. Class 150, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Kitz Corporation.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Powell Valves.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.9 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Division.
d. Flo Fab Inc.
e. Hammond Valve.
f. Kitz Corporation.
g. Legend Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Powell Valves.
k. Red-White Valve Corporation.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Flo Fab Inc.
e. Hammond Valve.
f. Kitz Corporation.
g. Legend Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Powell Valves.
k. Red-White Valve Corporation.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.

g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Iron Gate Valves, OS&Y, Class 250

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Crane Fluid Systems; Crane Co.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. Victaulic Company.
f. WATTS; A Watts Water Technologies Company.
g. Zurn Industries, LLC.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free

2.10 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following:**

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Kitz Corporation.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Powell Valves.
h. Red-White Valve Corporation.
i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.

b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron.

2.11 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Nordstrom Valves, Inc.

2. Description:

   a. Standard: MSS SP-78, Type II.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Venturi.
   f. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Nordstrom Valves, Inc.

2. Description:

   a. Standard: MSS SP-78, Type II.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Venturi.
   f. Plug: Cast iron or bronze with sealant groove.

2.12 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball and butterfly valve stems.
3. Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve.
4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for ball, butterfly and gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly**,** or gate valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service except Steam: Ball valves.
4. Throttling Service, Steam: Globe valves.
5. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
    b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Ball Valves: Class 150, two piece, full port, brass or bronze with stainless-steel trim.
2. Bronze Swing Check Valves: Class 150, bronze disc.
3. Bronze Gate Valves: Class 150, bronze.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 250 CWP, EPDM seat, aluminum-bronze disc.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron, Single-Flange High Performance Butterfly Valves, NPS 24 to NPS 48: 200 CWP, EPDM seat, aluminum-bronze disc.
4. Iron Swing Check Valves: Class 150, metal seats.
5. Iron Gate Valves: Class 150.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves 1” and Smaller: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, brass or bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 125, bronze disc.
4. Bronze Gate Valves: Class 125, NRS.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron, Single-Flange High Performance Butterfly Valves, NPS 24 to NPS 48: 200 CWP, EPDM seat, aluminum-bronze disc.
4. Iron Swing Check Valves: Class 125, metal seats.
5. Iron Globe style silent lift valves: Class 125,
6. Iron Gate Valves: Class 125.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Ball Valves: Two piece, full port, brass or bronze with stainless-steel trim.
2. Bronze Swing Check Valves: Class 125, bronze disc.
3. Bronze Gate Valves: Class 125, NRS.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
3. Iron Swing Check Valves: Class 125, metal seats.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 150, bronze disc.
2. Ball Valves: Two piece, full port, brass or bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, bronze disc.
4. Bronze Gate Valves: Class 150, RS.
5. Bronze Globe Valves: Class 150, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Swing Check Valves: Class 250, metal seats.
2. Iron Gate Valves: Class 250, OS&Y.
3. Iron Globe Valves, NPS 2-1/2 to NPS 12: Class 250.
4. Butterfly Valves: Single-Flange (Lug-Type), High-Performance Butterfly Valves, Class 150.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 150, bronze disc.
2. Ball Valves: Two piece, full port, brass or bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, bronze disc.
4. Bronze Gate Valves: Class 150, RS, bronze.
5. Globe Valves: Class 150, bronze, nonmetallic disc.

B. Pipe Sizes NPS 2-1/2 and Larger:

1. Iron Swing Check Valves: Class 250, metal seats.
2. Iron Gate Valves: Class 250, OS&Y.
3. Butterfly Valves: Single-Flange (Lug-Type), High-Performance Butterfly Valves, Class 150.

3.10 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Ball Valves: Two piece, full port, brass or bronze with stainless-steel trim.
2. Bronze Swing Check Valves: Class 125, bronze disc.
3. Bronze Gate Valves: Class 125, RS.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Swing Check Valves: Class 125, metal seats.
2. Iron Gate Valves: Class 125, NRS.
3. Butterfly Valves: Single-Flange (Lug-Type), High-Performance Butterfly Valves, Class 150.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2.

C. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Equipment supports.

D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.

2. Include design calculations for designing trapeze hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

C. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 after a seismic event.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Provide Seismic restraints for instrumentation systems that meet or exceeds site seismic requirements below;
   a. Seismic Design Category C
   b. Seismic Risk Category IV
   c. Seismic Use Group III
   d. Component Importance Factor, **I_p = 1.5**
   e. Component Response Modification Factor, **R_p= 12.0**
   f. Component Amplification Factor, **a_p = 2.5**

g. Short Term Spectral Response Acceleration Factor, **S_{ds} = 12.64 % g**
h. Long Period Spectral Response Acceleration Factor, **S_{d1} = 9.36% g**
i. Structural Safety Factor **= 4.0**

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized carbon steel or stainless steel.

B. Stainless Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel or stainless steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, [**provide products by the following**] [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

1. Buckaroos, Inc.
2. Pipe Shields Inc.
3. Piping Technology & Products, Inc.

4. Rilco Manufacturing Co., Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi, ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate and approved for seismic use for supported loads and building materials where used.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Hilti, Inc.
b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
c. MKT Fastening, LLC.

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate and approved for seismic use for supported loads and building materials where used.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Cooper B-line; brand of Eaton, Electrical Sector.
b. Hilti, Inc.
c. ITW Ramset/Red Head; Illinois Tool Works, Inc.
d. MKT Fastening, LLC.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

D. Metal or Fiberglass Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

F. Fastener System Installation:

1. Install seismically rated and approved powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install seismically rated and approved mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install lateral bracing with pipe hangers and supports to prevent swaying.

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

O. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
    f. NPS 30 : 28 inches long and .12 inches thick
    g. NPS 36: 34 inches long and.12 inches thick
    h. NPS 42: 40 inches long and .134 inches thick
    i. NPS 48: 46 inches long and .134 inches thick

5. Pipes NPS 8 and Larger: Include wood, cellular glass insulation, or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 and MSS SP-127-2014A: Bracing for Piping Systems: Seismic-Wind-Dynamic Design , Selection, and Application for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use galvanized or painted carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 48 .
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 48 , requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 48 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.

7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 48 .
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 48 , with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 48 , with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 48 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 36 , from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 36 , from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 48 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 48if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
22. Structural H slide assembly MSS-SP-69 and58 (type35): Carbon Steel “H” section , PTFE bonded slide plates and carbon steel base for support of piping with horizontal movement in one or two directions in same plane. Size NPS 8 to NPS 48.
23. Structural T side Assembly (MSS-SP-69 and 58) (TYPE 35): Carbon Steel “T” section , PTFE bonded slide plates and carbon steel base for support of piping with horizontal movement in one or two directions in same plane. Size NPS 3 to NPS 6.
24.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
3. NPS 30 to NPS 48: Carbon steel, alloy or stainless steel (MSS Type 42) with field welded shear lugs.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230533 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes heat tracing for freeze prevention of HVAC piping with self-regulating, parallel-resistance, electric heating cables:

B. Related Requirements:

1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
2. Section 220533 "Heat Tracing for Plumbing Piping."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables and controls to include in operation and maintenance manuals.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Chromalox, Inc.
2. RAYCHEM; brand of nVent Electrical plc.
3. Thermon Americas Inc.

B. Source Limitations: Obtain all heat tracing from one manufacturer.

C. Standard: IEEE 515.1.

D. Heating Element: Pair of parallel No. 16 AWG, tinned, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length.

E. Electrical Insulating Jacket: Flame-retardant polyolefin.

F. Grounding Cover: Tinned-copper braid.

G. Cable Cover: Tinned-copper or Stainless steel braid and polyolefin outer jacket with ultraviolet inhibitor.

H. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable is to be capable of crossing over itself once without overheating.

I. Maximum Operating Temperature (Power On): 150 deg F.

J. Maximum Exposure Temperature (Power Off): 185 deg F.

K. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

L. Capacities and Characteristics:

1. Minimum Heat Output: 3 W/ft**.**
   a. Heat Trace cable type and sizing to be based on pipe diameter, fluid material and freeze protection requirements.
2. Electrical Characteristics for Single-Circuit Connection:

   a. Volts: 120 V.
   b. Phase: **1**.
   c. Hertz: **60 Hz** Hz.
   d. Maximum Overcurrent Protection:20 A.

2.2 CONTROLS

A. Pipe-Mounted Thermostats for Freeze Protection:

1. Remote bulb temperature-control unit with adjustable range from 30 to 50 deg F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote temperature-sensing bulb on capillary, resistance temperature device, or thermistor for directly sensing ambient air or pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

B. Control Panel:

1. Microprocessor-based Automatic control with manual on, automatic, and standby/reset switch.
2. Remote temperature sensors sense outside air temperature; programmable to energize the cable when temperature falls below 34 to 44 deg F.
3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30 A contactor to energize cable or close other contactors.
5. Ground-fault protection.
6. Single-point control of heat tracing for freeze protection.
7. Provide communication ports for Ethernet interface for remote monitoring and alarm by central BMS-control system. Coordinate type of connection ports with Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: See Section 230553 "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install electric heating cable at locations indicated and in accordance with NFPA 70.

B. Install electric heating cable across expansion, construction, and control joints in accordance with manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.

C. Install electric heating cables after piping has been tested and before insulation is installed.

D. Install electric heating cables in accordance with IEEE 515.1.

E. Install insulation over piping with electric cables in accordance with Section 230719 "HVAC Piping Insulation."

F. Install warning tape on piping insulation where piping is equipped with electric heating cables.

G. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install temperature-control units in an accessible location and in accordance with manufacturer's written instructions. Locate sensing bulbs to sense outside air temperature in a location where it will not be affected by direct sunlight or other heat sources.

I. Install control panels and distribution panels where indicated and in accordance with manufacturer's written instructions.

J. Install outside air and pipe temperature sensors.

3.3 ELECTRICAL CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Connect temperature-control unit to interrupt power supply to electric heating cable when outside air is above set point.

D. Connect remote electronic temperature sensors.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings, such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

D. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

E. Cables will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION 230533

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraints - rigid type.
16. Restraints - cable type.
17. Restraint accessories.
18. Post-installed concrete anchors.
19. Concrete inserts.
20. Vibration isolation equipment bases.
21. Restrained isolation roof-curb rails.

B. Related Requirements:

1. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.

1.2 DEFINITIONS

A. Designated Seismic System: An HVAC component that requires design in accordance with ASCE/SEI 7, Ch. 13, and for which the Component Importance Factor is greater than 1.0.

B. IBC: International Building Code.

C. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each wind-force-restraint fitting and assembly.
3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic- and wind-force-restraint component.
4. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by [**ICC-ES product listing**] [**UL product listing**] [**FM Approvals**] [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].
5. Annotate to indicate application of each product submitted and compliance with requirements.
6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For [**professional engineer**] [**and**] [**testing agency**].

C. Welding certificates.

D. Air-Spring Isolator Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

E. Field quality-control reports.

F. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in [**ASCE/SEI 7-05,**] [**ASCE/SEI 7-10,**] [**ASCE/SEI 7-16,**]

Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.

1. Provide equipment manufacturer's written certification for each designated active mechanical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction [**or**] [**experience data as permitted by**] [**ASCE/SEI 7-05**] [**ASCE/SEI 7-10**] [**ASCE/SEI 7-16**].
2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in [**ASCE/SEI 7-05**] [**ASCE/SEI 7-10**] [**ASCE/SEI 7-16**].
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For [**air-spring isolators**] [**and**] [**restrained-air-spring isolators**] to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: [**ICC-ES product listing**] [**UL product listing**] [**FM Approvals**] [**an evaluation service member of ICC-ES**] [**an agency acceptable to authorities having jurisdiction**].

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Design Calculations:

1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in [**ASCE/SEI 7-05**] [**ASCE/SEI 7-10 including supplement No. 1**] [**ASCE/SEI 7-16**] <**Insert ASCE/SEI 7 edition or other seismic calculation method required by authorities having jurisdiction**>. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the Section Text.

   a. Data indicated below to be determined by Delegated Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
   b. Building Occupancy Category: IV.
   c. Building Risk Category: IV.
   d. Building Site Classification: C.

2. Calculation Factors, ASCE/SEI 7-16, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-16 unless otherwise noted.

   a. Horizontal Seismic Design Force F_p: Value is to be calculated by Delegated Design Contractor using Equation 13.3-1. Factors below must be obtained for this calculation:
      1) S_{DS} = Spectral Acceleration: .12% g.. Value applies to all components on Project.
      2) a_p = Component Amplification Factor: See Drawing Schedule for each component.
      3) I_p = Component Importance Factor: 1.5
      4) W_p = Component Operating Weight: For each component. Obtain by Delegated Design Contractor from each component submittal.
      5) R_p = Component Response Modification Factor: See Drawing Schedule for each component.
      6) z = Height in Structure of Point of Attachment of Component for Base: Determine from Project Drawings for each component by Delegated Design Contractor. For items at or below the base, "z" to be taken as zero.
      7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated Design Contractor.

   b. Vertical Seismic Design Force: Calculated by Delegated Design Contractor using method explained in ASCE/SEI 7-16, Paragraph 13.3.1.2.

c. Seismic Relative Displacement D_{pl}: Calculate by Delegated Design Contractor using methods explained in ASCE/SEI 7-10, Paragraph 13.3.2. Factors below must be obtained for this calculation:

1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculate by Delegated Design Contractor in accordance with ASCE/SEI 7-10, Paragraph 13.3.2.
2) I_e = Structure Importance Factor: <**Insert value**>. Value applies to all components on Project.
3) δ_{xA} = Deflection at Building Level x of Structure A: See Drawing Schedule for each component.
4) δ_{yA} = Deflection at Building Level y of Structure A: see Drawing Schedule for each component.
5) δ_{yB} = Deflection at Building Level y of Structure B: See Drawing Schedule for each component.
6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
8) Δ_{aA} = Allowable Story Drift for Structure A: See Drawing Schedules for each component.
9) Δ_{aB} = Allowable Story Drift for Structure B: See Drawing Schedules for each component.
10) h_{sx} = Story Height Used in the Definition of Allowable Drift Δ_a: See Drawings Schedules for each component.

d. Component Fundamental Period T_p: Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.3. Factors below must be obtained for this calculation:

1) W_p = Component Operating Weight: Determined by Contractor from Project Drawings and manufacturer's data.
2) g = Gravitational Acceleration: 32.17 fps2.
3) K_p = Combined Stiffness of Component, Supports, and Attachments: Determined by delegated design seismic engineer. <**Insert value**>.

3. Calculation Factors, ASCE/SEI 7-10, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-10 unless otherwise noted.

a. Horizontal Seismic Design Force F_p: Calculated by Delegated Design Contractor by ASCE/SEI 7-10, Equation 13.3-1. Factors below must be obtained for this calculation:
1) S_{DS} = Spectral Acceleration: <**Insert value**>. Value applies to all components on Project.

2) a_p = Component Amplification Factor: See Drawing Schedule for each component.
3) I_p = Component Importance Factor: See Drawing Schedule for each component.
4) W_p = Component Operating Weight: For each component. Obtain by Delegated Design Contractor from equipment submittal.
5) R_p = Component Response Modification Factor: See Drawing Schedule for each component.
6) z = Height in Structure of Point of Attachment of Component for Base: Determined from Project Drawings for each component by Contractor. For items at or below the base, "z" to be taken as zero.
7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated Design Contractor.

b. Vertical Seismic Design Force: Calculate by Delegated Design Contractor using method explained in ASCE/SEI 7-10, Paragraph 13.3.1.
c. Seismic Relative Displacement D_{pl}: Calculate by Delegated Design Contractor using methods explained in ASCE/SEI 7-10, Paragraph 13.3.2. Factors below must be obtained for this calculation:

1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculate by Delegated Design Contractor in accordance with ASCE/SEI 7-10, Paragraph 13.3.2.
2) I_e = Structure Importance Factor: <**Insert value**>. Value applies to all components on Project.
3) δ_{xA} = Deflection at Building Level x of Structure A: See Drawing Schedule for each component.
4) δ_{yA} = Deflection at Building Level y of Structure A: see Drawing Schedule for each component.
5) δ_{yB} = Deflection at Building Level y of Structure B: See Drawing Schedule for each component.
6) h_x = Height of Level x to which Upper Connection point Is Attached: Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data;
7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
8) Δ_{aA} = Allowable Story Drift for Structure A: See Drawing Schedule for each component.
9) Δ_{aB} = Allowable Story Drift for Structure B: See Drawing Schedule for each component.
10) h_{sx} = Story Height Used in the Definition of Allowable Drift Δ_a: See Drawing Schedule for each component.

4. Calculation Factors, ASCE/SEI 7-05, Ch. 3 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-05 unless otherwise noted.

a. Horizontal Seismic Design Force F_p: Calculated by Delegated Design Contractor by ASCE/SEI 7-05, Equation 13.3-1. Factors below must be obtained for this calculation:
   1) S_{DS} = Spectral Acceleration: <**Insert value**>. Value applies to all components on Project.
   2) a_p = Component Amplification Factor: See Drawing Schedule for each component.
   3) I_p = Component Importance Factor: See Drawing Schedule for each component.
   4) W_p = Component Operating Weight: Obtain by Delegated Design Contractor for each component from component submittal.
   5) R_p = Component Response Modification Factor: See Drawing Schedule for each component.
   6) z = Height in Structure of Point of Attachment of Component for Base: Determine by Delegated Design Contractor for each component from Project Drawings. For items at or below the base, "z" to be taken as zero.
   7) h = Average Roof Height of Structure for Base: Determine by Delegated Design Contractor from Project Drawings.

b. Vertical Seismic Design Force: Calculated by Delegated Design Contractor using method explained in ASCE/SEI 7-05, Paragraph 13.3.1.

c. Seismic Relative Displacement D_p: Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-05, Paragraph 13.3.2. Factors below must be obtained for this calculation:
   1) δ_{xA} = Deflection at Building Level x of Structure A: See Drawing Schedule for each component.
   2) δ_{yA} = Deflection at Building Level y of Structure A: See Drawing Schedule for each component.
   3) δ_{yB} = Deflection at Building Level y of Structure B: See Drawing Schedule for each component.
   4) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
   5) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
   6) Δ_{aA} = Allowable Story Drift for Structure A: See Drawing Schedule for each component.
   7) Δ_{aB} = Allowable Story Drift for Structure B: See Drawing Schedule for each component.
   8) h_{sx} = Story Height Used in the Definition of Allowable Drift Δ_a: See Drawing Schedule for each component.

B. Consequential Damage: Provide additional seismic restraints for suspended HVAC components or anchorage of floor-, roof-, or wall-mounted HVAC components as indicated in [**ASCE/SEI 7-05**] [**ASCE/SEI 7-10**] [**ASCE/SEI 7-16**] so that failure of a

non-essential or essential HVAC component will not cause failure of any other essential architectural, mechanical, or electrical building component.

C. Fire/Smoke Resistance: Seismic-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

D. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
2. All component support attachments must comply with force and displacement resistance requirements of [**ASCE 7-05 Section 13.6**] [**ASCE/SEI 7-10 Section 13.6**] [**ASCE/SEI 7-16 Section 13.6**].

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain elastomeric isolation pads from single manufacturer.
3. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
4. Size: Factory or field cut to match requirements of supported equipment.
5. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
6. Surface Pattern: Smooth, ribbed, or waffle pattern.
7. Infused nonwoven cotton or synthetic fibers.
8. Load-bearing metal plates adhered to pads.
9. Sandwich-Core Material: [**Resilient**] [**and**] [**elastomeric**] <**Insert compound**>.

    a. Surface Pattern: Smooth, ribbed, or waffle pattern.
    b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain double-deflection, elastomeric isolation mounts from single manufacturer.

3. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded[**with threaded studs or bolts**].
    b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

4. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain restrained elastomeric isolation mounts from single manufacturer.
3. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

    a. Housing: Cast-ductile iron or welded steel.
    b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain freestanding, laterally stable, open-spring isolators from single manufacturer.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates limit floor load to 500 psig.
8. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain freestanding, laterally stable, open-spring isolators in two-part telescoping housing from single manufacturer.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to 500 psig.
    b. Top housing with [**attachment and leveling bolt**] [**threaded mounting holes and internal leveling device**] [**elastomeric pad**].

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain restrained-spring isolators from single manufacturer.
3. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to 500 psig.
    b. Top plate with [**threaded mounting holes**] [**elastomeric pad**].
    c. Internal leveling bolt that acts as blocking during installation.

4. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
5. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
6. Minimum Additional Travel: 50 percent of the required deflection at rated load.
7. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

8. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain freestanding, open-spring isolators with vertical-limit stop restraints from single manufacturer.
3. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with [**adjustable**] [**non-adjustable**] snubbers to limit vertical movement.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to 500 psig.
    b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- Thick Neoprene: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain all-directional, acoustical pipe anchor from single manufacturer.
3. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
4. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- Thick Neoprene: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain resilient pipe guides from single manufacturer.
3. Factory-Set Height Guide with Shear Pin: Shear pin to be removable and reinsertable to allow for selection of pipe movement. Guides to be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain elastomeric hangers from a single manufacturer.
3. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
4. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: .

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain spring hangers from single manufacturer.
3. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain snubbers from single manufacturer.

C. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with [**ACI 318-08 Appendix D for 2009 IBC**] [**ACI 318-11 Appendix D for 2012 IBC**] [**ACI 318-14 Ch. 17 for 2015 or 2018 IBC**].
2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.14 RESTRAINTS - RIGID TYPE

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain rigid-type restraints from single manufacturer.

C. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.15 RESTRAINTS - CABLE TYPE

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain cable-type restraints from single manufacturer.

C. Seismic-Restraint Cables: [**ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel**] [**ASTM A492 stainless steel**] cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

D. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.16 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-line; brand of Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut; Atkore International.

B. Source Limitations: Obtain restraint accessories from single manufacturer.

C. Hanger-Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod. Non-metallic stiffeners are unacceptable.

D. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to [**rigid channel bracings**] [**and**] [**restraint cables**].

E. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

F. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.17 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cooper B-line; brand of Eaton, Electrical Sector.
b. Hilti, Inc.
c. Mason Industries, Inc.
d. Powers Fasteners.
e. Unistrut; Atkore International.

2. Source Limitations: Obtain mechanical anchor bolts from single manufacturer.
3. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cooper B-line; brand of Eaton, Electrical Sector.
b. Hilti, Inc.
c. Mason Industries, Inc.
d. Powers Fasteners.
e. Unistrut; Atkore International.

2. Source Limitations: Obtain adhesive anchor bolts from single manufacturer.
3. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of [**ASCE/SEI 7-05, Ch. 13**] [**ASCE/SEI 7-10, Ch. 13**] [**ASCE/SEI 7-16, Ch. 13**].

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.

1. Undercut expansion anchors are permitted.

2.18 CONCRETE INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-line; brand of Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Powers Fasteners.
5. Unistrut; Atkore International.

B. Source Limitations: Obtain concrete inserts from single manufacturer.

C. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC466 testing.

D. Comply with ANSI/MSS SP-58.

2.19 VIBRATION ISOLATION EQUIPMENT BASES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain vibration isolation equipment bases from single manufacturer.

C. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails to have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases to have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

E. Concrete Inertia Base: Factory-fabricated or field-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases to have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.20 RESTRAINED ISOLATION ROOF-CURB RAILS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain restrained isolation roof-curb rails from single manufacturer.

C. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic forces.

D. Upper Frame: To provide continuous support for equipment and to be captive to resiliently resist seismic forces.

E. Lower Support Assembly: To be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. Lower support assembly to have a means for attaching to building structure and a wood nailer for attaching roof materials, and to be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Mount adjustable, restrained-spring isolators on elastomeric vibration isolation pads and provide access ports, for level adjustment, with removable waterproof covers at all isolator locations. Locate isolators so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.

F. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

G. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraintdevices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

C. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

D. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

F. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**] that provides required submittals for component.

G. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of [**40 feet**] <**Insert dimension**> o.c., and longitudinal supports a maximum of [**80 feet**] <**Insert dimension**> o.c.
3. Brace a change of direction longer than 12 feet.

H. Ductwork Restraints:

1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with [**SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."**] [**SMACNA's "Seismic Restrain Manual: Guidelines for Mechanical Systems - OSHPD Edition."**] [**ASCE/SEI 7.**][**See Section 233113 "Metal Ducts" for Seismic Hazard Level (SHL).**][**See Section 233113 "Metal Ducts" for "Connection Level" performance requirement for OSHPD jurisdictions.**] <**Insert requirement.**>
2. Space lateral supports a maximum of [**40 feet**] <**Insert dimension**> o.c., and longitudinal supports a maximum of [**80 feet**] <**Insert dimension**> o.c.
3. Brace a change of direction longer than 12 feet.
4. Select seismic-restraint devices with capacities adequate to carry static and seismic loads.
5. Install cable restraints on ducts that are suspended with vibration isolators.

I. Install seismic-restraint cables so they do not bend across edges of adjacent equipment or building structure.

J. Install seismic-restraint devices using methods approved by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**] that provides required submittals for component.

K. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

L. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

M. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

N. Mechanical Anchor Bolts:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors to be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Provide flexible connections in piping systems where they cross structural seismic joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.5 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate dimensions of steel equipment rails and bases, concrete inertia bases, and restrained isolation roof-curb rails with requirements of isolated equipment specified in this and other Sections. Where dimensions of these bases are indicated on Drawings, dimensions may require adjustment to accommodate actual isolated equipment.

3.6 ADJUSTING

A. Adjust isolators after system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. Perform tests and inspections with the assistance of a factory-authorized service representative.
2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
6. Test to 90 percent of rated proof load of device.
7. Measure isolator restraint clearance.
8. Measure isolator deflection.
9. Verify snubber minimum clearances.
10. Test and adjust restrained-air-spring isolator controls and safeties.

D. Remove and replace malfunctioning units and retest as specified above.

E. Units will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.
   5. Stencils.
   6. Valve tags.
   7. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Pre-coiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Paint: Exterior, gloss, black unless otherwise indicated. Paint may be in pressurized spray-can form.
   2. Identification Paint: Exterior, in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   2. Color: Yellow background with black lettering.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For supply, mixed-air and outdoor air ducts.
   2. Green: For exhaust-, relief-, and return- air ducts.

3. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:
   a. Variable-air-volume systems.
2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
   a. Variable-flow hydronic systems.
3. Testing, adjusting, and balancing of fuel oil systems for HVAC.
4. Testing, adjusting, and balancing of steam and condensate piping systems.
5. Testing, adjusting, and balancing of equipment.
6. Vibration tests.
7. HVAC-control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

G. UFAD: Underfloor air distribution.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

A. Sustainable Design Submittals:

1. Air-Balance Report: Documentation indicating that Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.7 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by NEBB or TABB:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

D. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning in accordance with the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in ASHRAE 111 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
   1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
   1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
   2. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
   3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units.

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

   1. Motors.
   2. Pumps.
   3. Fans.
   4. Terminal units.
   5. Boilers.
   6. Deaerators.
   7. Unit heaters.
   8. Heat exchangers.
   9. Water chillers.
   10. Cooling towers.
   11. Energy-recovery units.
   12. Air-handling units.
   13. Heating-only makeup air units.
   14. Dedicated outdoor-air units.
   15. Computer-room air conditioners.
   16. Coils.
   17. Fan coil units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
d. Adjust controls so that terminal is calling for minimum airflow.
e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.
c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

6. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Balance the return-air ducts and inlets.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.
    c. Re-measure final fan operating data, speed, volts, amps, and static profile.
    d. Mark final settings.
    e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
    f. Verify tracking between supply and return fans.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check expansion tank for proper setting.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
5. Verify that motor controllers are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.
7. Check permanently installed flow meters are installed and calibrated.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

1. Check settings and operation of each safety valve. Record settings.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the pressure-differential sensor(s) is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:

1. Adjust pumps to deliver total design flow.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.
    d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

    a. Measure differential pressure and verify that it is within manufacturer's specified range.
    b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

    a. Measure and balance coils by either coil pressure drop or temperature method.
    b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that total flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

D. For systems with flow diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.
3. Adjust pumps to deliver total design flow.

    a. Measure total water flow.

        1) Position valves for full flow through coils.

2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

a. Measure differential pressure, and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
c. Mark final settings.

3.9 PROCEDURES FOR STEAM AND CONDENSATE SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.10 PROCEDURES FOR STEAM-TO-WATER HEAT EXCHANGERS

A. Adjust and record water flow to within specified tolerances.

B. Measure and record inlet and outlet water temperatures.

C. Measure and record inlet steam pressure and condensate outlet pressure.

D. Check and record settings and operation of safety and relief valves.

3.11 PROCEDURES FOR WATER-TO-WATER HEAT EXCHANGERS

A. Adjust and record water flow to within specified tolerances.

B. Measure and record inlet and outlet water temperatures.

C. Measure and record pressure drop.

D. Check and record settings and operation of safety and relief valves.

3.12 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.13 PROCEDURES FOR WATER CHILLERS

A. Water-Cooled Chillers: Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at maximum and minimum design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. Condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.

6. Capacity: Calculate in tons and kilowatts of cooling.
7. Efficiency: Calculate operating efficiency for comparison to submitted equipment.

3.14 PROCEDURES FOR COOLING TOWERS

A. Performance Testing: Comply with CTI ATC-105.

B. Open-Circuit Cooling Towers: Balance total condenser-water flows to towers and cells. Measure and record the following data:

1. Condenser-water flow to each cell of the cooling tower.
2. Pressure at each inlet connection.
3. Entering- and leaving-water temperatures.
4. Range.
5. Makeup-water flow rate.
6. Makeup water temperature.
7. Wet- and dry-bulb temperatures of entering air.
8. Wet- and dry-bulb temperatures of leaving air.
9. Approach.
10. Barometric pressure, wind speed, and wind direction.
11. Fan, motor, and motor controller operating data.
12. Fan Variable-frequency controller settings and operating data.
13. Basin heater operating data.

3.15 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Measure and record pressure drop.
4. Capacity: Calculate in Btu/h of heating output.
5. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.
6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
7. Fan, motor, and motor controller operating data.

B. Steam Boilers:

1. Measure and record entering-water temperature.
2. Measure and record feedwater flow.
3. Measure and record leaving-steam pressure and temperature.
4. Measure and Record relief valve(s) pressure setting.
5. Capacity: Calculate in Btu/h of heating output.
6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
7. Fan, motor, and motor controller operating data.

C. Boilers with Flue Gas Economizers:

1. Measure and record entering- and leaving-water temperature.
2. Measure and record water flow rate.
3. Measure and record water pressure drop.
4. Heat Recovered: Calculate in Btu/h of waste heat recovered.

3.16 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each hydronic coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

3.17 VIBRATION TESTS

A. After systems are balanced and Substantially Completion, measure and record vibration levels on equipment having motor horsepower equal to or greater than 15.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.

2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from AABC's "National Standards for Total System Balance." Acceptable levels of vibration are normally "smooth" to "good."
4. Include in General Machinery Vibration Severity Chart, with conditions plotted.

3.18 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.19 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, within 10 cfm.
2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, within 10 cfm.
3. Heating-Water Flow Rate: Plus 10 percent or minus 5 percent. If design value is less than 10 gpm, within 10 percent.
4. Chilled-Water Flow Rate: Plus 10 percent or minus 5 percent. If design value is less than 10 gpm, within 10 percent.
5. Condenser-Water Flow Rate: Plus 10 percent or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.20 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including the following:

a. Indicated versus final performance.
b. Notable characteristics of systems.
c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:

a. Settings for outdoor-, return-, and exhaust-air dampers.
b. Conditions of filters.
c. Cooling coil, wet- and dry-bulb conditions.
d. Heating coil, dry-bulb conditions.
e. Face and bypass damper settings at coils.
f. Fan drive settings, including settings and percentage of maximum pitch diameter.
g. Variable-frequency controller settings for variable-air-volume systems.
h. Settings for pressure controller(s).
i. Other system operating conditions that affect performance.

16. Test conditions for pump performance forms, including the following:

a. Variable-frequency controller settings for variable-flow hydronic systems.
b. Settings for pressure controller(s).
c. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.

f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Inlet and discharge static pressure in inches wg.
e. For each filter bank, filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.

j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and speed.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.

i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.
f. BHP and VFD speed at maximum flowrate.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System fan and air-handling-unit number.

b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump speed.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

M. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.21 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Construction Manager.

3.22 ADDITIONAL TESTS

A. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, supply and outdoor air.
2. Indoor, return located in unconditioned space.
3. Indoor, exhaust between isolation damper and penetration of building exterior.
4. Outdoor, concealed supply and return.

B. Related Requirements:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Product Data: For adhesives, indicating VOC content.
3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
4. Product Data: For coatings, indicating VOC content.
5. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
6. Product Data: For sealants, indicating VOC content.
7. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.

4. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 233113 – “Metal Ducts."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. Knauf Insulation.
c. Owens Corning.

F. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 250 deg F for jacketed and between 35 deg F and 450 deg F for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Johns Manville; a Berkshire Hathaway company.
    b. Knauf Insulation.
    c. Owens Corning.

2.3 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Foster Brand; H. B. Fuller.
    d. Mon-Eco Industries, Inc.
2. Verify adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
3. Verify adhesive complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Dow Consumer Solutions.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Speedline Corporation.
2. Verify adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
3. Verify adhesive complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.4 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

1. VOC Content: 300 g/L or less.
2. Low-Emitting Materials: Verify mastic coatings comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Vapor-Retarder Mastic, Water Based, Interior Use: Suitable for indoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller.
   c. Knauf Insulation.

2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 20 to plus 180 deg F.

2.5 SEALANTS

A. FSK Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller.
   d. Mon-Eco Industries, Inc.

2. Materials are compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. Verify sealant has a VOC content of 250 g/L or less.
7. Verify sealant complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.7 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M Industrial Adhesives and Tapes Division.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

B. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M Industrial Adhesives and Tapes Division.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.

b. RPR Products, Inc.

2. Stainless Steel: ASTM A240/A240M, Type 304; 0.015 inch thick, 3/4 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Nelson Stud Welding.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Nelson Stud Welding.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, stainless steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Nelson Stud Welding.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. C & F Wire Products.
b. Johns Manville; a Berkshire Hathaway company.
c. RPR Products, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor

insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF GLASS-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Comply with manufacturer's written installation instructions.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FINISHES

A. Do not field paint aluminum or stainless steel jackets.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to six location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.8 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. All Supply and Outdoor air duct.
2. Return duct located in unconditioned space and where indicated on the drawings.
3. Exhaust duct between isolation damper and penetration of building exterior.
    a. All ductwork connected to outside, exhaust and relief plenums and fans shall be insulated to the nearest control damper, plus an additional 10 linear feet past the damper.
4. Outdoor air, relief and exhaust Plenums.

B. Items Not Insulated:
1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

3.9 DUCT AND PLENUM INSULATION SCHEDULE

A. Supply-air duct insulation is the following:
1. Glass-Fiber Blanket: 2 inches thick and 1 lb/cu. ft. nominal density.

B. Return-air duct in non conditioned spaces and mechanical/electrical rooms insulation is the following:
1. Glass-Fiber Blanket: 2 inches thick and 1 lb/cu. ft. nominal density.

C. All Outdoor-air duct and any exhaust or relief air duct between exterior opening and final damper, duct insulation shall be the following:
   1. Glass-Fiber Board: 2 inches thick and 3 lb/cu. ft. nominal density.
   2. Insulate all exhaust and relief duct minimum of 10 additional feet out from exterior opening.

D. Outdoor-air, exhaust and relief plenum insulation is one of the following:
   1. Glass-Fiber Board: 2 inches thick and 3 lb/cu. ft. nominal density.

END OF SECTION 230713

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating HVAC equipment that is not factory insulated.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail removable insulation at equipment connections.
2. Detail application of field-applied jackets.
3. Detail application at linkages of control devices.
4. Detail field application for each equipment type.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket

materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule," "Indoor Equipment Insulation Schedule," and "Outdoor, Aboveground Equipment Insulation Schedule? articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I or Type II.

1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Johns Manville; a Berkshire Hathaway company.

G. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type II for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA.
b. Armacell LLC.

H. Mineral-Fiber Blanket: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II, and ASTM C1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CertainTeed Corporation.
b. Johns Manville; a Berkshire Hathaway company.
c. Knauf Insulation.
d. Owens Corning.

I. High-Temperature, Mineral-Fiber Blanket: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type V, without factory-applied jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. Knauf Insulation.

J. Mineral-Fiber Board: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CertainTeed Corporation.
b. Johns Manville; a Berkshire Hathaway company.
c. Knauf Insulation.
d. Owens Corning.

K. High-Temperature, Mineral-Fiber Board: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type III, without factory-applied jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. Rockwool International.

L. Mineral-Fiber, Pipe and Tank: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C1393.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CertainTeed Corporation.
b. Johns Manville; a Berkshire Hathaway company.

c. Knauf Insulation.
d. Owens Corning.

2. Semirigid board material with factory-applied [**ASJ**] [**FSK**] jacket.
3. Nominal density is 2.5 lb/cu. ft. or more.
4. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.
5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ramco Insulation, Inc.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ramco Insulation, Inc.

2.4 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Vimasco Corporation.

C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA.
b. Armacell LLC.

c. Foster Brand; H. B. Fuller Construction Products.

2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
3. Wet Flash Point: Below 0 deg F
4. Service Temperature Range: 40 to 200 deg F.
5. Color: Black .

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.

E. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Mon-Eco Industries, Inc.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.5 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor and outdoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Knauf Insulation.

2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
5. Color: White.

C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to 180 deg F.
4. Color: White.

2.6 LAGGING ADHESIVES

A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.7 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 58 to plus 176 deg F.
4. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

D. ASJ Flashing Sealants and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Childers Brand; H. B. Fuller Construction Products.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.8 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

2.10 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Johns Manville; a Berkshire Hathaway company.
    b. P.I.C. Plastics, Inc.
    c. Proto Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.

2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper 2.5-mil-thick polysurlyn.
    d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper 2.5-mil-thick polysurlyn.
    e. Factory-Fabricated Fitting Covers:

        1) Same material, finish, and thickness as jacket.
        2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.
        8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white stucco-embossed aluminum-foil facing.

F. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.

G. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. 3M Industrial Adhesives and Tapes Division.
b. Ideal Tape Co., Inc., an American Biltrite Company.
c. Knauf Insulation.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

2.13 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; 0.106-inch-diameter shank, length to suit depth of insulation indicated.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.080-inch nickel-copper alloy or 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, **available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**:

a. C & F Wire Products.
b. Johns Manville; a Berkshire Hathaway company.
c. RPR Products, Inc.

2.14 CORNER ANGLES

A. PVC Corner Angles: 30-mils-thick, minimum 1- by 1-inch PVC in accordance with ASTM D1784, Class 16354-C, white or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040-inch-thick, minimum 1- by 1-inch aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless Steel Corner Angles: 0.024-inch-thick, minimum 1- by 1-inch stainless steel in accordance with ASTM A240/A240M, Type 304.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, and jackets, of thicknesses required for each item of equipment, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

O. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.

3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive, anchor pins, and speed washers.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for 50 minimum percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints and 16 inches o.c. in both directions.
    d. Do not over-compress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins, and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
2. Fabricate boxes from stainless steel, at least 0.050 inch thick.
3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings:

1. Secure single-layer insulation with stainless steel bands at 12-inch intervals, and tighten bands without deforming insulation material.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.8 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: No painting will be required.

3.9 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections.

B. Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

E. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in "Indoor Equipment Insulation Schedule" and "Outdoor, Aboveground Equipment Insulation Schedule? articles. For large equipment, remove only a portion adequate to determine compliance.

F. All insulation applications will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.10 EQUIPMENT INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Acceptable insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials is Contractor's option.

3.11 GENERATOR COMPONENTS INSULATION SCHEDULE

A. Removable exhaust manifold, turbo exhaust and inlet casing, intercooler piping and connector insulation shall be the following:
   1. High-Temperature Mineral-Fiber Blanket: 2inches thick and 6-lb/cu. ft. nominal density.
   2. Inner, Outer & Gusset Jacketing: 17 oz./sq.yd. Teflon coated fiberglass cloth
   3. Thread: Teflon coated fiberglass
   4. Fastening Devices: Belts made of jacketing material with S.S. double D rings.

B. Muffler insulation shall be one of the following:

   1. Calcium Silicate: 4 inches thick.

2. High-Temperature Mineral-Fiber Blanket: 3 inches thick and 3-lb/cu. ft. nominal density.
3. High-Temperature Mineral-Fiber Board: 3 inches thick and 3-lb/cu. ft. nominal density.

3.12 INDOOR EQUIPMENT INSULATION SCHEDULE

A. Insulate indoor and outdoor equipment that is not factory insulated.

B. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with the following:
1. Flexible Elastomeric: 1 inch thick.

C. Heat-exchanger (water-to-water for heating service) insulation shall be the following:
1. Flexible Elastomeric: 1 inch thick.

D. Chilled-water pump insulation shall be the following:
1. Flexible Elastomeric: 1 inch thick.

E. Heating-hot-water pump insulation shall be one of the following:

1. Calcium Silicate: 3 inches thick.
2. Cellular Glass: 3 inches thick.
3. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

F. Chilled-water expansion/compression tank insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick.

G. Heating-hot-water expansion/compression tank insulation shall be one of the following:

1. Calcium Silicate: 2 inches thick.
2. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
3. Mineral-Fiber Pipe and Tank: 1 inch thick.

H. Piping system filter-housing insulation shall be one of the following:

1. Cellular Glass: 3 inches thick.
2. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
3. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:
   1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces of up to 72 Inches:
   1. Aluminum, Stucco Embossed: 0.020 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. Aluminum, Stucco Embossed with 4-by-1-Inch Box Ribs: 0.032 inch thick.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

   1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces of up to 72 Inches:

   1. Aluminum, Stucco Embossed: 0.024 inch thick.

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Chilled-water and brine piping, indoors and outdoors.
2. Heating hot-water piping, indoors and outdoors.
3. Refrigerant suction and hot-gas piping, indoors and outdoors.
4. Outdoor condenser water piping.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230716 "HVAC Equipment Insulation."

1.2 ACTION SUBMITTALS

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Johns Mansville.
    b. Knauf.
    c. Owens Corning.

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Aeroflex USA, Inc.
    b. Armacell LLC.
    c. K-Flex USA.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 1290, Type I.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. CertainTeed Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Knauf Insulation.

d. Manson Insulation Inc.
e. Owens Corning.

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. Knauf Insulation.
c. Manson Insulation Inc.
d. Owens Corning.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied with factory-applied ASJ-SSL.
3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

2.3 MASTICS And Sealants

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

2.4 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.5 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.6 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White.
   3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Factory cut and rolled to size.
   2. Finish and thickness are indicated in field-applied jacket schedules.
   3. Moisture Barrier for Indoor Applications: 2.5-mil- thick polysurlyn.
   4. Moisture Barrier for Outdoor Applications: 2.5-mil- thick polysurlyn.
   5. Factory-Fabricated Fitting Covers:
      a. Same material, finish, and thickness as jacket.

E. Stainless Steel Jacket: ASTM A240/A240M.
   1. Factory cut and rolled to size.
   2. Finish and thickness are indicated in field-applied jacket schedules.
   3. Moisture Barrier for Indoor Applications: 2.5-mil- thick polysurlyn.
   4. Moisture Barrier for Outdoor Applications: 2.5-mil- thick polysurlyn.
   5. Factory-Fabricated Fitting Covers:
      a. Same material, finish, and thickness as jacket.

F. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

2.7 TAPES

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

2.8 SECUREMENTS

A. Aluminum Bands, Staples, or Wire

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.

4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends inside building. Provide outdoor vapor barrier, and insulation weather tight jacket at indoor transition and extend through roof. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation through roof flashing at least 2 inches below roof deck.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends inside building. Provide outdoor vapor barrier, and insulation weather tight jacket at indoor transition and extend through wall. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation through wall flashing and transition to indoor insulation at least 2 inches inside wall.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate fittings using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids.
3. Insulate valves and strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams.
4. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
5. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

C. Install removable insulation covers at service location and identification stamp locations.

D. Finishes
1. Pipe Insulation with ASJ or Other Paintable Jacket Material:
    a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
    b. Finish Coat Material: Interior, flat, latex-emulsion size.]
    c. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
    d. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

e. Do not field paint aluminumjackets

3.5 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.

3.6 INDOOR PIPING INSULATION SCHEDULE

A. Insulation shall meet requirements of Local Energy Code and/or ASHRAE Standard 90.1 (2019) Section 6.8.3

B. Service Water Heating and makeup water
1. 141°F - 200°F: Cellular Glass, or Mineral Fiber: Conductivity 0.25 – 0.29

Pipe Size	Insulation Thickness
<1 ½”	Min. 1.5”
4” – >8”	Min. 2”

C. Cooling Systems (Chilled Water, Refrigerant, Brine)
1. <40°F Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
All sizes	Min 1.5”

D. Cooling Systems (Chilled Water, Condenser Water, Refrigerant, Brine)
1. 40°F-60°F Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
All Sizes	Min. 1”

E. Cooling Systems Condensate Drains
1. Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
All sizes	Min. 1”

F. Steam Condensate, Boiler Blowdown, Vents, Drains, and Safety Relief Vents:
1. Cellular Glass, or Mineral Fiber: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
1-1/2” and below	Min. 1”
1-1/2” and above”	Min 2”

G. High Pressure Steam:
1. Cellular Glass, or Mineral Fiber: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
3/4” and below	Min. 3.5”
1” to 1-1/2”	Min 4”
2” and above	Min 5”

H. Refrigerant Suction and Hot-Gas Piping or Tubing:
1. 40°F-60°F Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.20 – 0.26

Pipe Size	Insulation Thickness
All Sizes	Min. 1”

3.7 INDOOR, FIELD-APPLIED JACKET

A. Install factory applied FSK jacket over insulation material.

3.8 OUTDOOR PIPING INSULATION SCHEDULE

A. Insulation shall meet or exceed requirements of Local Energy Code and/or Latest edition of ASHRAE Standard 90.1 Section 6.8.3 and scheduled values below.

B. Provide outdoor pipe insulation with protective weather resistant jacket and moisture barrier jacket. Extend insulation and protective jacket assembly through roofs and walls.

C. On heat traced outdoor piping systems adjust insulation pipe size diameter to accommodate electric heat trace cables and sensors. Extend electric heat trace on piping through roofs and walls per manufacturer’s instructions. Heat tracing shall be based on -20 outdoor ambient and 40 degree pipe temperature unless indicated otherwise.

D. Makeup water
1. 40°F - 60°F: Cellular Glass, or Mineral Fiber: Conductivity 0.25 – 0.29

Pipe Size	Insulation Thickness
All Sizes	Min. 1.5”

E. Cooling Systems (Chilled Water, Refrigerant)
1. <40°F: Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
All sizes	Min 1.5”

F. Cooling Systems (Chilled Water, Condenser Water, Refrigerant)
1. 40°F-60°F Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
Up to 14”	Min. 1.5”
15” to 24”	Min 2”.0

G. Cooling Systems Condensate and Equipment Drains and Overflows
1. Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.22 – 0.28

Pipe Size	Insulation Thickness
All sizes	Min. 1.5”

H. Refrigerant Suction, Hot-Gas and Liquid Piping or Tubing:
1. <40°F: Cellular Glass, Mineral Fiber, or Flexible Elastomeric: Conductivity 0.20 – 0.26

Pipe Size	Insulation Thickness
All sizes	Min 1.5”

3.9 OUTDOOR, FIELD-APPLIED JACKET

A. Install jacket over insulation material and moisture vapor barrier. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Size insulation and jacket to accommodate heat tracing where heat traced pipes are indicated.

C. If more than one material is listed, selection from materials listed is Contractor's option.

D. Outdoor piping:
1. PVC: 30 mils thick.
2. Aluminum, Smooth: 0.024 inch thick.
3. Stainless Steel, Type 304, Smooth 2B Finish: 0.024 inch thick.

E. Provide moisture vapor barrier on all outdoor piping over insulation.

F. Seal insulation protective jacket longitudinal, transverse joints. Provide insulation jacket manufacturer's recommended overlap but in all case not less than 2" overlap. Secure jacket with mastic, adhesive and draw bands. Do not use staples, screws or rivets. Seal flashing to jacket joints.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning Specifications and requirements to be supplied at a later date by the commissioning agent.

END OF SECTION 230800

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct digital control (DDC) system equipment and components for monitoring and controlling of cooling water, chilled water, water treatment, steam, heating hot water, and HVAC, exclusive of instrumentation and control devices.

2. Extent of control system is captured on the drawings, P&IDs, sequence of operations and related specification sections.

B. Related Requirements:

1. Section 230923.11 “Control Valves" for automated valves that connect to DDC systems.
2. Section 230923.12 “Control Dampers" for automated dampers that connect to DDC systems.
3. Section 230923.13 "Energy Meters" for thermal and electric power energy meters that connect to DDC systems.
4. Section 230923.14 “Flow Instruments" for air and water based flow detection and measuring devices that connect to DDC systems.
5. Section 230923.17 "Level Instruments" for liquid-level switches, sensors, and transmitters that connect to DDC systems.
6. Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.
7. Section 230923.23 “Pressure Instruments" for air and water based pressure measuring sensors and switches that connect to DDC systems.
8. Section 230923.27 “Temperature Instruments" for air and water based temperature measuring sensors and switches that connect to DDC systems.
9. Section 230923.33 "Vibration Instruments" for vibration instruments that connect to DDC systems.
10. Section 230923.43 "Weather Stations" for weather stations that connect to DDC systems.
11. Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
12. Division 25 “Integrated Automation”
13. Section 270553 "Identification for Communications Systems" for identification requirements for communications components.

1.2 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.

J. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

K. HLC: Heavy load conditions.

L. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

M. LAN: Local area network.

N. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

O. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

P. Modbus TCP/IP: An open protocol for exchange of process data.

Q. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

R. MTBF: Mean time between failures.

S. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

T. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

U. Peer to Peer: Networking architecture that treats all network stations as equal partners.

V. POT: Portable operator's terminal.

W. RAM: Random access memory.

X. RF: Radio frequency.

Y. Router: Device connecting two or more networks at network layer.

Z. Server: Computer used to maintain system configuration, historical and programming database.

AA. TCP/IP: Transport control protocol/Internet protocol.

BB. UPS: Uninterruptible power supply.

CC. USB: Universal Serial Bus.

DD. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

EE. VAV: Variable air volume.

FF. WLED: White light emitting diode.

1.3 PRE-DESIGN COORDINATION AND MEETINGS

A. Owner/Integrator Coordination
   1. This controls system shall integrate into a campus and company-wide control scheme. Provide coordination meetings during system design to determine owner's requirements.
   2. Conduct meetings with Owner's chosen campus integrator. Implement the Integrator's requirements for communication, data transfer, parameter quantity and type, and control scheme.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Location of Owner's Choice.

B. Trending and Sampling Strategies Conference: Conduct conference at Location of Owner's Choice.

C. Security and Access Conference: Conduct conference at Location of Owner's Choice.

D. Graphics Conference: Conduct conference at Location of Owner's Choice.

1.5 ACTION SUBMITTALS

A. Multiple Submissions:

   1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
   2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
   3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

    a. Workstations.
    b. Servers.
    c. Gateways.
    d. Routers.
    e. Protocol analyzers.
    f. DDC controllers.
    g. Enclosures.
    h. Electrical power devices.
    i. Accessories.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:
1. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
2. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
3. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
4. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:

1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.

2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:

a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
c. Each desktop workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
e. Network communication cable and raceway routing.
f. Proposed routing of wiring, cabling, conduit, and tubing; coordinated with building services for review before installation.

6. Schematic drawings for each controlled HVAC system indicating the following:

a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
c. A graphic showing location of control I/O in proper relationship to HVAC system.
d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
e. Unique identification of each I/O that to be consistently used between different drawings showing same point.
f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
g. Narrative sequence of operation.
h. Graphic sequence of operation, showing all inputs and output logical blocks.

7. Control panel drawings indicating the following:

a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.

b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
c. Front, rear, and side elevations and nameplate legend.
d. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:

a. Each device connected to network with unique identification for each.
b. Interconnection of each different network in DDC system.
c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type/source panel name-circuit number) listed for each.
b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

a. Control signal cable and wiring between controllers and I/O.
b. Point-to-point schematic wiring diagrams for each product.
c. Control signal tubing to sensors, switches, and transmitters.
d. Process signal tubing to sensors, switches, and transmitters.

11. Color graphics indicating the following:

a. Itemized list of color graphic displays to be provided.
b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
c. Intended operator access between related hierarchical display screens.

E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.

2. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

    a. Loss of power.
    b. Loss of network communication signal.
    c. Loss of controller signals to inputs and outpoints.
    d. Operator workstation failure.
    e. Server failure.
    f. Gateway failure.
    g. Network failure.
    h. Controller failure.
    i. Instrument failure.
    j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

F. Sustainable Design Submittals:

1. ENERGY STAR: Product Data for indicated products, showing compliance with requirements for ENERGY STAR product labeling.
2. Product Data: For adhesives and sealants, indicating VOC content.
3. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved.
2. Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved.

B. Welding certificates.

C. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

D. Test and Evaluation Reports:

1. Product Test Reports: For each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Source Quality-Control Submittals:

1. Source quality-control reports.

F. Sample warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system.

1. In addition to items specified in Section 017823 “Operation and Maintenance Data,” include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator’s manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
f. Engineering, installation, and maintenance manuals that explain how to do the following:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

g. List of recommended spare parts with part numbers and suppliers.
h. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
i. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
j. Licenses, guarantees, and warranty documents.
k. Owner training materials.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials and parts to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list to be indicated for each year.

1.9 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of 10 years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least three past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

    a. Product research and development.
    b. Product and application engineering.
    c. Product manufacturing, testing, and quality control.
    d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
    e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. Demonstrate past experience with installation of DDC system products being installed for period within three consecutive years before time of bid.
3. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
4. Service and maintenance staff assigned to support Project during warranty period.
5. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.
6. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

1.10 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Adjust, repair, or replace failures at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Perform warranty service during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

a. For Gateway: Three-year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS/INTEGRATORS

A. Manufacturers/Integrators: Subject to compliance with requirements, provide products by one of the following:

1. Conserv Building Automation Systems.

2. Distech Controls
3. Honeywell International Inc.
4. Johnson Controls, Inc.
5. Johnson FX
6. KMC Controls
7. Open Control Systems (OCS)
8. Siemens Industry, Inc., Building Technologies Division.
9. Shambaugh

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system consisting of peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

A. DDC system to be web compatible.

1. Web-Compatible Access to DDC System:

a. This interface is for programming and maintenance only. All user interfaces will occur through the Owner's campus control system.

b. Workstation and server to perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
c. DDC system to support web browser access to building data. Operator using a standard web browser is able to access control graphics and change adjustable set points.
d. Password-protected web access.

2.4 OWNER'S GATEWAY CONNECTION

A. DDC system to include components to connect via ethernet to the owner's campus control system
1. Control system requirements are determined by the Owner's contracted Integrator.
2. Campus control system is to be located remotely.
3. All user interfacing to the system will occur through the campus control system. Direct connection to the DDC is for maintenance and programming only.
4. Local control of the DDC will occur via connection to the campus control system using the local ethernet network.

2.5 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. DDC system for monitoring and controlling of cooling water, chilled water, steam, heating hot water, chemical treatment, and HVAC systems.

B. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to control systems installers for field installation.

C. Delegated Design, Qualified Professional: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

a. DDC system manages all building systems including:
1) Cooling water
2) Chilled water
3) Steam
4) Heating hot water
5) Chemical treatment
6) Airside HVAC equipment
7) Steam Boiler Feedwater
8) Steam Boiler Condensate Receiver
9) Steam Boiler Continuous Blowdown Heat RecoveryAll associated pumping for systems listed above

b. DDC system operates systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
c. DDC system responds to power failures, equipment failures, and adverse and emergency conditions encountered through connected I/O points.
d. DDC system operates while unattended by an operator and through operator interaction.
e. DDC system records trends and transactions of events and produces report information such as performance, energy, occupancies, and equipment operation.

D. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths complying with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

E. DDC System Speed:

1. Response Time of Connected I/O:

a. Update AI point values connected to DDC system at least every two seconds for use by DDC controllers. Points used globally to also comply with this requirement.
b. Update BI point values connected to DDC system at least every two seconds for use by DDC controllers. Points used globally to also comply with this requirement.
c. AO points connected to DDC system to begin to respond to controller output commands within two second(s). Global commands to also comply with this requirement.

d. BO point values connected to DDC system to respond to controller output commands within two second(s). Global commands to also comply with this requirement.

2. Display of Connected I/O:

a. Update and display analog point COV connected to DDC system at least every five seconds for use by operator.
b. Update and display binary point COV connected to DDC system at least every five seconds for use by operator.
c. Update and display alarms of analog and digital points connected to DDC system within 15 seconds of activation or change of state.
d. Update graphic display refresh within four seconds.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.

F. Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:

1. Level 1 Networks: 20 Mbps.
2. Level 2 Networks: 20 Mbps.
3. Level 3 Networks: 20 Mbps.

G. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.
2. Local Storage:

a. Provide server with data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

H. DDC Data Access:

1. When logged into the Owner’s campus control system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.
2. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

I. Future Expandability:

1. DDC system size is expandable to an ultimate capacity of at least 1.5 times total I/O points indicated.
2. Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
3. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.

J. Input Point Values Displayed Accuracy: See associated drawings and specifications for required accuracy. Where that accuracy isn't listed, meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:

a. Thermal: Within 1 percent of reading.
b. Electric Power: Within 1 percent of reading.
c. Requirements indicated on Drawings for meters not supplied by utility.

2. Flow:

a. Air: Within 3 percent of design flow rate.
b. Air (Terminal Units): Within 5 percent of design flow rate.
c. Fuel Oil: Within 2 percent of design flow rate.
d. Natural Gas: Within 2 percent of design flow rate.
e. Water: Within 2 percent of design flow rate.
f. Steam: Within 5 percent of design flow rate.

3. Gas:
a. Refrigerant: Within 5 percent of reading.

4. Moisture (Relative Humidity):

a. Air: Within 2 percent RH.
b. Space: Within 2 percent RH.
c. Outdoor: Within 2 percent RH.

5. Pressure:

a. Air, Ducts and Equipment: 1 percent of instrument span.
b. Space: Within 1 percent of instrument span.
c. Water: Within 1 percent of instrument span.
d. Steam: Within 1 percent of instrument span.

6. Temperature, Dry Bulb:

a. Air: Within 0.5 deg F.
b. Space: Within 0.5 deg F.
c. Outdoor: Within 1 deg F.
d. Chilled Water: Within 0.5 deg F.
e. Condenser Water: Within 0.5 deg F.
f. Heating Hot Water: Within 0.5 deg F.
g. Steam: Within 1 deg F.
h. Temperature Difference: Within 0.1 deg F.
i. Other Temperatures Not Indicated: Within 0.5 deg F.

7. Temperature, Wet Bulb:

a. Air: Within 0.5 deg F.
b. Space: Within 0.5 deg F.
c. Outdoor: Within 1 deg F.

8. Vibration: Within 5 percent of reading.

K. Precision of I/O Reported Values See associated drawings and specifications for required precision. Where that precision isn't listed, values reported in database and displayed to have following precision:

1. Current:

a. Milliamperes: Nearest 1/100th of a milliampere.
b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

a. Electric Power:

1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

b. Fuel Oil (Usage): For gallons, nearest 1/10th of a gallon up to 100 gal.; nearest gallon for above 100 gal..
c. Natural Gas (Usage): Nearest 1/10th of a unit (cubic feet, MCF, therm) up to 100 units; nearest unit for above 100 units.
d. Thermal, Rate:

1) Heating: For British thermal units per hour, nearest British thermal unit per hour up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For MBh,

round to nearest MBh up to 1000 MBh; nearest 10 MBh between 1000 and 10,000 MBh; nearest 100 MBh above 10,000 MBh.

2) Cooling: For tons, nearest 1/10th ton up to 1000 tons; nearest ton above 1000 tons.

e. Thermal, Usage:

1) Heating: For British thermal unit, nearest British thermal unit up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu.

2) Cooling: For ton-hours, nearest 1/10th ton-hour up to 1000 ton-hours; nearest ton-hour above 1000ton-hours.

3. Flow:

a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
b. Fuel Oil: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm
c. Natural Gas: Nearest 1/10th of a cubic feet per hour through 100 cfh; nearest cubic feet per hour between 100 and 1000 cfh; nearest 10 cfh between 1000 and 10,000 cfh; nearest 100 cfh above 10,000 cfh.
d. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.
e. Steam: Nearest 1/10th of a pound per hour through 100 lb/h; nearest pound per hour between 100 and 1000 lb/h; nearest 10 lb/h above 1000 lb/h.

4. Gas:
a. Refrigerant (ppm): Nearest ppm.

5. Moisture (Relative Humidity):

a. Relative Humidity (Percentage): Nearest 1 percent.

6. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
7. Pressure:

a. Air, Ducts and Equipment: Nearest 1/10th of an inch water closet.
b. Space: Nearest 1/100th of an inch water closet.
c. Steam: Nearest 1/10th of pounds per square inch gauge through 100 psig; nearest pounds per square inch gauge above 100 psig.
d. Water: Nearest 1/10 of a pound per square inch gauge through 100 psig; nearest pound per square inch gauge above 100 psig.

8. Temperature:

    a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
    b. Outdoor: Nearest ½ of a degree.
    c. Space: Nearest 1/10th of a degree.
    d. Chilled Water: Nearest 1/10th of a degree.
    e. Condenser Water: Nearest 1/10th of a degree.
    f. Heating Hot Water: Nearest 1/10th of a degree.
    g. Steam: Nearest degree.

9. Vibration: Nearest 1/10th of an inch per second.
10. Voltage: Nearest 1/10 V up to 100 V; nearest volt above 100 V.

L. Control Stability: See associated drawings and specifications for required control stability. Where that stability isn't listed, control variables indicated within the following limits:

1. Flow:

    a. Air, Ducts and Equipment, except Terminal Units: Within 2 percent of design flow rate.
    b. Air, Terminal Units: Within 5 percent of design flow rate.
    c. Water: Within 2 percent of design flow rate.
    d. Steam: Within 5 percent of design flow rate.

2. Moisture (Relative Humidity):

    a. Air: Within 2 percent RH.
    b. Space: Within 2 percent RH.
    c. Outdoor: Within 2 percent RH.

3. Pressure:

    a. Air, Ducts and Equipment: 1 percent of instrument span.
    b. Space: Within 1 percent of instrument span.
    c. Water: Within 1 percent of instrument span.
    d. Steam: Within 1 percent of instrument span.

4. Temperature, Dry Bulb:

    a. Air: Within 0.5 deg F.
    b. Space: Within 0.5 deg F.
    c. Chilled Water: Within 0.5 deg F.
    d. Condenser Water: Within 0.5 deg F.
    e. Heating Hot Water: Within 0.5 deg F.

5. Temperature, Wet Bulb:

    a. Air: Within 0.5 deg F.

b. Space: Within 0.5 deg F.

M. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.

a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.

2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 12.
b. Outdoors, Unprotected: Type 4X.
c. Indoors, Heated with Filtered Ventilation: Type 2.
d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
e. Indoors, Heated and Air-Conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 12.
2) Air-Moving Equipment Rooms: Type 12.

g. Localized Areas Exposed to Washdown: Type 4X.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
j. Hazardous Locations: Explosion-proof rating for condition.

N. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure is internally insulated, electrically heated, and ventilated as required by instrument and application.

2. Protect instruments, actuators, and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House instruments and actuators not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location is to dictate the following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 12.
    b. Outdoors, Unprotected: Type 4X.
    c. Indoors, Heated with Filtered Ventilation: Type 2.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
    e. Indoors, Heated and Air-conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: Type 12.
        2) Air-Moving Equipment Rooms: Type 12.

    g. Localized Areas Exposed to Washdown: Type 4X.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
    i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
    j. Hazardous Locations: Explosion-proof rating for condition.

O. DDC System Reliability:

1. Design, install, and configure DDC controllers, gateways, and routers, to yield a MTBF of at least 40,000 hours, based on a confidence level of at least 90 percent. MTBF value includes any failure for any reason to any part of products indicated.
2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment being controlled, operational, and under automatic control.
3. See Drawings for critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated.

P. Electric Power Quality:

1. Power-Line Surges:

    a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
    b. Do not use fuses for surge protection.
    c. Test protection in the normal mode and in the common mode, using the following two waveforms:

        1) 10-by-1000-microsecond waveform with a peak voltage of 1500 V and a peak current of 60 A.

2) 8-by-20-microssecond waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner are as follows:

1) At 85 percent load, output voltage to not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage to not deviate by more than 2 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion to not exceed 2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.

Q. Backup Power Source:

1. The DDC controls will be connected to a generator backed UPS system. All power in the building is connected to this emergency power.

R. UPS:

1. The DDC will be served from a centralized UPS system provided under specification section 263353 “Static Uninterruptible Power Supply” and electrical drawings.

2. DDC system products powered by UPS units are to include the following:

a. Servers.
b. Gateways.
c. DDC controllers.
d. Desktop workstations.

3. DDC system instruments and actuators powered by UPS units are to include the following:

a. Damper Actuators: Where indicated on Drawings; where associated with the following systems controlled by DDC system:

1) Generator Room.

2) Air Inlet Monitor.

S. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.6 SYSTEM ARCHITECTURE

A. System architecture consisting of no more than levels of LANs.

1. Level 1 LAN: Connect network controllers to Owner's campus control system via a Tridium Niagara gateway. Control workstations will connect to Owner's campus control system.
2. Level 2 LAN: Connect programmable application controllers to other programmable application controllers and to network controllers.
3. Level 3 LAN: Connect application-specific controllers to programmable application controllers and to network controllers.

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
2. LAN Connecting Programmable Application Controllers: 1000 kbps.
3. LAN Connecting Application-Specific Controllers: 115,000 bps.

C. Provide dedicated DDC system LANs that are not shared with other building systems and tenant data and communication networks.

D. Provide modular system architecture with inherent ability to expand to not less than 1.5 times system size indicated with no impact to performance indicated.

E. Configure architecture to minimize need to remove and replace existing network equipment for system expansion.

F. Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.

G. Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing own control, alarm management, and historical data collection.

H. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling-system air-handling unit(s). Basically, create DDC system LAN that aligns with air-handling system being controlled.

2.7 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator able to access entire DDC system through any of multiple means including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port to Owner's campus control system.
2. Portable operator terminal with hardwired connection through LAN port to Owner's campus control system.
3. Portable operator workstation with wireless connection through LAN router to Owner's campus control system.
4. Mobile device and application with secured wireless connection through LAN router or cellular data service to Owner's campus control system.
5. Remote connection through web access shall be prohibited.

B. Make access to system, regardless of operator means used, transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. The boiler room.
3. The chiller room.
4. Each outdoor on-grade yard, mezzanine and elevated platform with equipment connected to DDC system.
5. Each different roof level with roof-mounted equipment connected to DDC system.
6. Security system command center.
7. Fire-alarm system command center.

D. Desktop Workstations:

1. Connect desktop workstation(s) to Owner's campus control system through building LAN. Access the DDC system Level 1 LAN is through the Owner's campus control system.
2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:

1. Connect portable workstation(s) to Owner's campus control system through building LAN. Access the DDC system Level 1 LAN through the Owner's campus control system.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system Level 3 LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Connect to system through a wireless router connected to Level 1 LAN.
5. Connect to system through a cellular broadband data service.
6. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
7. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected.

G. Mobile Device (Tablet and Smart Phone):

1. Connect Owner-furnished mobile devices to system through a local wireless router connected to Owner's campus control system through building LAN.
2. Able to communicate with any DDC controller connected to DDC system using dedicated application and secure web access.

H. Critical Alarm Reporting:

1. Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
2. Send alarm notification to multiple recipients that are assigned for each alarm.
3. Notify recipients by any or all means, including email, text message, and prerecorded phone message to mobile and landline phone numbers.

I. Simultaneous Operator Use: Capable of accommodating up to 10 simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.8 NETWORK COMMUNICATION PROTOCOL

A. Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.

B. Industry Standard Protocols:

1. Use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

a. ASHRAE 135.

b. Modbus Application Protocol Specification V1.1b3.

2. Operator workstations and network controllers are to communicate through ASHRAE 135 protocol.
3. Provide portions of DDC system networks using ASHRAE 135 communication protocol as an open implementation of network devices complying with ASHRAE 135. Use network devices that are tested and listed by BTL.
4. Provide portions of DDC system networks using Modbus Application Protocol Specification V1.1b3 communication protocol as an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b3.
5. Use gateways to connect networks and network devices with different protocols.

2.9 SERVERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Dell Technologies Inc.
2. HP Inc.
3. Lenovo Holding Co., Inc.; Lenovo Group Ltd.

B. Description: x86-based permanently installed computer used for client-server computing.

C. Mounting: Rack or Tower able to be rack mounted.

D. Power: Dual power supply, minimum 300W.

E. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. ENERGY STAR compliant.
3. Minimum Processor Speed: as required to meet performance requirements of systems under control
4. RAM:

a. Capacity: As required to meet performance requirements indicated.
b. Speed and Type: As required to meet performance requirements indicated.

5. Redundant Array of Independent Discs: One configuration.
6. Drive Bays: Eight at 2.5 inches or eight at 3.5 inches.
7. Hard-Drive Storage: As required to meet storage requirements indicated.
8. Network Interface: Dual-port gigabit Ethernet or Optical fiber.
9. DVD +RW drive.
10. Color, flat-screen display with10 inch minimum diagonal viewable area.

11. Keyboard and mouse.
12. Next-day on-site warranty for two-year period following Substantial Completion.

F. Servers are to include the following:

1. Full-feature backup server (server and backup minimum requirement).
2. Software licenses.
3. Cable installation between server(s) and network.

G. Web Server:

1. If required to be separate, include web server hardware and software to match, except backup server is not required.
2. Firewalls between server web and networks.
3. Password protection for access to server from web server.
4. Cable installation between the server(s) and building Ethernet network.

H. Power each server through building centralized UPS power.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system capable of operating DOS and Microsoft Windows applications.
3. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.

2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Make operator sign-off a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Make automatic sign-off period programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Record operator sign-on and sign-off activity.
6. Security Access:

    a. Use password control for operator access to DDC system.
    b. Assign an alphanumeric password (field assignable) to each operator.
    c. Grant operators access to DDC system by entry of proper password.
    d. Use same operator password regardless of which computer or other operator interface means are used.
    e. Automatically update additions or changes made to passwords.
    f. Assign each operator an access level to restrict access to data and functions the operator is cable of performing.
    g. Provide software with at least five access levels.
    h. Assign each menu item an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
    i. Display menu items to operator with those capable of access highlighted. Make menu and operator access level assignments online programmable and under password control.

7. Data Segregation:

    a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
    b. Include at least 32 segregation groups.
    c. Make segregation groups selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
    d. Make points assignable to multiple segregation groups. Display and output of data to printer or monitor is to occur where there is a match of operator or peripheral segregation group assignment and point segregations.
    e. Make alarms displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
    f. Assign operators and peripherals to multiple segregation groups and make all assignments online programmable and under password control.

8. Operators able to perform commands including, but not limited to, the following:

    a. Start or stop selected equipment.
    b. Adjust set points.
    c. Add, modify, and delete time programming.
    d. Enable and disable process execution.
    e. Lock and unlock alarm reporting for each point.

f. Enable and disable totalization for each point.
g. Enable and disable trending for each point.
h. Override control loop set points.
i. Enter temporary override schedules.
j. Define holiday schedules.
k. Change time and date.
l. Enter and modify analog alarm limits.
m. Enter and modify analog warning limits.
n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.

9. Reporting:

a. Generated automatically and manually.
b. Sent to displays, printers and disc files.
c. Types of Reporting:

1) General listing of points.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.

5. Make graphic displays online user definable and modifiable using the hardware and software provided.
6. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
7. Make graphics online programmable and under password control.
8. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics to also contain software points.
10. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected to facilitate operator understanding.
11. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.
14. Include operator with means to directly access graphics without going through penetration path.
15. Make dynamic data assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
18. Provide dynamic points with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, command points directly from display using pointing device.

    a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
    b. For a digital command point such as valve position, show valve in current state such as open or closed so operator could select alternative position using pointing device.
    c. Include a keyboard equivalent for those operators with that preference.

20. Give operator ability to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot, and other information on other quadrants on screen. This feature allows real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

    a. Online context-sensitive help utility to facilitate operator training and understanding.

b. Bridge to further explanation of selected keywords and contain text and graphics to clarify system operation.

1) If help feature does not have ability to bridge on keywords for more information, provide a complete set of user manuals in an indexed word-processing program, which runs concurrently with operating system software.

c. Available for Every Menu Item:

1) Index items for each system menu item.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

a. Room layouts with room identification and name.
b. Locations and identification of all monitored and controlled equipment and other equipment being monitored and controlled by DDC system.
c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of the following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.

E. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display is to include the following:

a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."

b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
d. Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.

5. Direct alarms to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send email alarm messages to designated operators.
7. Send email, page, text, and voice messages to designated operators for critical alarms.
8. Categorize and process alarms by class.

a. Class 1:

1) Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
3) All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.

b. Class 2:

1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
2) Acknowledgement may be through a multiple alarm acknowledgment.

c. Class 3:

1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
2) Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.
3) Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
4) Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.

2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.

F. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Setup each report so data content, format, interval, and date are operator definable.
3. Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
4. Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Store reports and logs on workstations and servers hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Make reports and logs readily printable and set to be print either on operator command or at a specific time each day.

G. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

H. Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.

I. HVAC Equipment Reports: Prepare Project-specific reports.

1. Chiller Report: Daily report showing operating conditions of each chiller in accordance with ASHRAE 147 including, but not limited to, the following:

a. Chilled-water entering temperature.
b. Chilled-water leaving temperature.
c. Chilled-water flow rate.
d. Chilled-water inlet and outlet pressures.
e. Evaporator refrigerant pressure and temperature.
f. Condenser refrigerant pressure and liquid temperature.
g. Condenser-water entering temperature.
h. Condenser-water leaving temperature.
i. Condenser-water flow rate.
j. Refrigerant levels.
k. Oil pressure and temperature.
l. Oil level.
m. Compressor refrigerant discharge temperature.
n. Compressor refrigerant suction temperature.
o. Addition of refrigerant.
p. Addition of oil.
q. Vibration levels or observation that vibration is not excessive.
r. Motor amperes per phase.
s. Motor volts per phase.
t. Refrigerant monitor level (PPM).
u. Purge exhaust time or discharge count.
v. Ambient temperature (dry bulb and wet bulb).
w. Date and time logged.

J. Utility Reports: Prepare Project-specific reports.

1. Electric Report:

a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
c. Include annual report showing monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
d. For each weekly, monthly, and annual report, include sum total of submeters combined by load type, such as lighting, receptacles, and HVAC equipment showing daily electrical consumption and peak electrical demand.
e. For each weekly, monthly, and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.

2. Natural Gas Report:

a. Include weekly, monthly, and annual report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.

b. For each weekly, monthly, and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
c. For each weekly, monthly, and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.

3. Service Water Report:

a. Include weekly, monthly, and annual report showing daily service water consumption and peak service water demand with time and date stamp for each meter.
b. For each weekly, monthly, and annual report, include sum total of submeters combined by load type, such as cooling tower makeup and irrigation showing daily service water consumption and peak service water demand.
c. For each weekly, monthly. and annual report, include sum total of all submeters in building showing service water consumption and peak service water demand.

K. Energy Reports: Prepare Project-specific daily, weekly, monthly, annual and since-installed energy reports.

1. Prepare report for each purchased energy utility, indicating the following:

a. Time being reported with beginning and end date, and time indicated.
b. Consumption in units of measure commonly used to report specific utility consumption over time.
c. Gross area served by utility.
d. Consumption per unit area served using utility-specific unit of measure.
e. Cost per utility unit.
f. Utility cost per unit area.
g. Convert all utilities to a common energy consumption unit of measure and report for each utility.
h. Consumption per unit area using common unit of measure.

2. Prepare report for each renewable energy source, indicating the following:

a. Time being reported with beginning and end date, and time indicated.
b. Harvested energy in units of measure commonly used to report specific harvested energy consumption over time.
c. Gross area served by renewable energy source.
d. Harvested energy per unit area served using specific unit of measure.
e. Cost per purchased utility unit displaced by renewable energy.
f. Cost savings attributed to harvested energy source.
g. Cost savings per unit area attributed to harvested energy.

h. Convert all renewable energy sources to a common energy consumption unit of measure and report for each.
i. Harvested energy per unit area using common unit of measure.

3. Prepare purchased energy utility report for each submetered area that indicates the following:

a. Time being reported with beginning and end date, and time indicated.
b. Gross area served.
c. Energy consumption by energy utility type.
d. Energy consumption per unit area by energy utility type.
e. Total energy consumption of all utilities in common units of measure.
f. Total energy consumption of all utilities in common units of measure per unit area.
g. Unit energy cost by energy utility type.
h. Energy cost by energy utility type.
i. Energy cost per unit area by energy utility type.
j. Total cost of all energy utilities.
k. Total cost of all energy utilities per unit area.

4. Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report is to indicate the following:

a. Time being reported with beginning and end date, and time indicated.
b. Gross area served.
c. Energy consumption by energy utility type.
d. Energy consumption per unit area by energy utility type.
e. Total energy consumption of all utilities in common units of measure.
f. Total energy consumption of all utilities in common units of measure per unit area.
g. Unit energy cost by energy utility type.
h. Energy cost by energy utility type.
i. Energy cost per unit area by energy utility type.
j. Total cost of all energy utilities.
k. Total cost of all energy utilities per unit area.

L. HVAC System Efficiency Reports: Prepare Project-specific daily, weekly, monthly, annual and since-installed HVAC system efficiency reports.

1. Prepare report for chilled-water system, indicating the following:

a. Time being reported with beginning and end date, and time indicated.
b. Cooling energy supplied during period.
c. Power energy consumed during period by cooling equipment used to produce cooling energy supplied. List power consumed for each individual piece of equipment in system and summed total of all equipment in system.

d. Energy efficiency coefficient of performance determined by dividing power energy consumed into cooling energy supplied.
e. Energy efficiency determined by dividing cooling energy supplied into power energy consumed.
f. Units of measure used in report to be consistent with units indicated for system.

2. Prepare report for heating hot-water system, indicating the following:

a. Time being reported with beginning and end date, and time indicated.
b. Heating energy supplied during period.
c. Fuel consumed during period by boilers used to produce heating energy supplied. List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.
d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
e. Units of measure used in report are to be consistent with units indicated for system.

3. Prepare report for steam system, indicating the following:

a. Time being reported with beginning and end date, and time indicated.
b. Heating energy supplied during period.
c. Fuel consumed during period by boilers used to produce heating energy supplied. List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.
d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
e. Units of measure used in report are to be consistent with units indicated for system.

4. Prepare report for air-side systems, indicating the following:

a. Time being reported with beginning and end date, and time indicated.
b. Heating energy supplied during period.
c. Fuel consumed during period by boilers used to produce heating energy supplied. List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.
d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
e. Units of measure used in report are to be consistent with units indicated for system.

M. Weather Reports:

1. Include daily report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.

b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
d. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F.
e. Daily minimum, maximum, and average relative humidity.
f. Daily minimum, maximum, and average barometric pressure.
g. Daily minimum, maximum, and average wind speed and direction.

2. Include weekly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
d. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F.
e. Daily minimum, maximum, and average relative humidity.
f. Daily minimum, maximum, and average barometric pressure.
g. Daily minimum, maximum, and average wind speed and direction.

3. Include monthly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
d. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F.
e. Daily minimum, maximum, and average relative humidity.
f. Daily minimum, maximum, and average barometric pressure.
g. Daily minimum, maximum, and average wind speed and direction.

4. Include annual (12-month) report showing the following:

a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
b. Monthly minimum, maximum, and average outdoor wet-bulb temperature.
c. Number of heating degree-days for each month calculated from a base temperature of 55 deg F.
d. Number of cooling degree-days for each month calculated from a base temperature of 65 deg F.
e. Monthly minimum, maximum, and average relative humidity.
f. Daily minimum, maximum, and average barometric pressure.
g. Daily minimum, maximum, and average wind speed and direction.

N. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Associate trends into groups, and setup a trend report for each group.
3. Store trends within DDC controller and uploaded to hard drives automatically on reaching 75 percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Make trend intervals operator selectable from 10 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 5000 per variable.
6. When drive storage memory is full, overwrite oldest data with most recent data.
7. Make archived and real-time trend data available for viewing numerically and graphically by operators.

O. Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.

1. Include each trend with interval, start time, and stop time.
2. Sample and store data on DDC controller, within reaching 75 percent storage limits of DDC controller, and then uploaded to archive on workstation or server hard drives.
3. Make data retrievable for use in spreadsheets and standard database programs.

2.11 ANALYTICS SOFTWARE

A. Scope: Incorporate analytics software into DDC System:

1. Licensing, without Recurring Cost: No re-occurring cost for licensing and subscriptions.

2. Purpose: Analyze energy and operational data to identify faults and opportunities for improved performance and reduced energy use.
3. Verification: Verify that HVAC systems and associated sequence of operations are executing as specified or as described on Drawings, through the analysis of energy and operational data, identification of faults showing where control sequences are not functioning as prescribed, and identification of opportunities for improved performance in the operation of systems.

B. Use during Project Life:

1. During Construction: Use for verification of performance during startup, commissioning, and final acceptance of DDC system.
2. During Warranty Period: Use for continuous operational tuning of DDC system and verification of operation and designed to identify warranty issues preemptively, thus reducing failures and potential down time.
3. After Warranty Period: Use to diagnose ongoing operational degradation and for Owner to perform continuous monitoring-based commissioning.

C. Minimum Features and Capabilities:

1. Operating Systems: Current version of Windows-based operating systems.
2. Time Series Database: Database technology, designed for efficient storage and analysis of large volumes of time series data, using tagging to model and describe data; supports an open-source tagging standard.
3. Data Import: Ability to accept and normalize data from a variety of sources including SQL compatible databases, CSV format files, XML format files or web services, and other EDI techniques. Once imported, software is to provide a unified data format to enable analytics algorithms to identify patterns across different data sets.
4. Open Interfaces: Open, REST-based APIs to enable integration with third-party software applications. Open APIs are to enable data to be entered/imported into database, exported from database, posting of analytic queries, and output of analytic results. APIs are to be fully documented and available as part of standard product.
5. Host: Local deployed on DDC system network.
6. Weather Data Service: Built-in worldwide weather service providing weather data including, but not limited to, the following:

    a. Current temperature.
    b. High temperature for the day.
    c. Low temperature for the day.
    d. Sunrise and sunset times.
    e. Relative humidity.
    f. Degree days (heating and cooling with adjustable balance point value).
    g. Seven-day forecast.
    h. Historical weather data extending back at least one year.

7. Email Notification: Automatic notification of detected issues via email including, but not limited to, the following:

    a. Immediate notification of detected issues.
    b. Daily digest or summary of detected issues.
    c. Ability to delineate which notifications are sent to which recipients down to the level of specifying individual issues sent to individual recipients.

D. Hardware Requirements:

1. Host on a server in a virtual environment complying with Owner's security requirements.
2. Comply with standard software and hardware profiles required by Owner.

E. Analytic Rules:

1. Custom Rule Development: Develop customized rules and algorithms tailored to operational needs and characteristics of individual facilities and needs of monitoring and verification project and fault-detection requirements of Project

without depending on manufacturer for rule development. Provide tools for user development and full documentation.

2. Standard Analytic Functions: Library of standard analytic functions is to use these standard analytic functions as elements to build custom analytic rules for specific needs of individual facilities.
3. Existing library of not less than 200 standard analytic rules written for applications similar to those required for this Project.

F. Reporting:

1. Standard Views of Analytic Results: Standard views to present analytic results, automatically generated when issues are found by analytic rules including, but not limited to, the following:

    a. Rules violations across a portfolio of sites, rules violations per site, including time, date, and duration of all violations.
    b. Ability to assign cost relationships to rule logic to provide cost per violation.
    c. Standard filters to enable operator to easily look at rule violations by site, data, and violation type for any selected date or date range.
    d. Automatic calculation and presentation of Key Performance Indicators (KPIs) and to define custom KPIs as needed.

2. Custom Views of Analytic Results:

    a. Any standard system view is to be able to be saved as a custom report including its configuration criteria, e.g., time range, sites, rule violations, or other configuration options as applicable to standard system view.
    b. Created by making queries against the database and saving the query as a saved report executed by single mouse click.
    c. Export: Support report views export into CSV, Excel, XML, and HTML format, accomplished in a couple of mouse clicks.

G. Energy-Specific Reporting and Information Presentation Tools:

1. Greenhouse Gas Analysis: Energy/carbon dioxide relationships; easily changed and added without involvement of software manufacturer.
2. Energy Baseline: Quantify and define energy consumption and demand baselines (including weather normalization metrics) and compare actual and forecasted energy demand and consumption against those baselines.
3. Benchmarking: Multisite benchmarking to compare energy consumption and demand profiles and baselines across all buildings within Owner's portfolio.
4. Forecasting: Forecast near-future loads by using historic trends and forecasted weather data.
5. Financial Analysis: Calculate costs based on energy consumption and demand and energy costs and associate costs with any faults discovered by any analytic function and perform model- or tariff-based calculations to determine costs.
6. Tracking of Key Performance Indicators: Definition and tracking of user-defined key performance indicators/operational metrics. Examples include energy

demand and consumption normalized for area and weather, peak demand, and consumption shown with minimum and maximum ranges across any user-selectable period.

7. Correlation of Energy Use with Equipment Operation: Automatically present views showing correlation between energy demand and consumption and operation of loads associated with that usage. Include the following:

    a. All submeters and virtual meters.
    b. Weather data as a selectable item.

H. Implementation:

1. Apply analytic rules to all HVAC systems and equipment monitored and controlled by DDC system. To extent available, use a subset of rules in existing rules library.
2. Implement rules to aid in determining proper operation of any HVAC system with a programmed sequence of operation.
3. Generate reports to aid in verification of proper operation during initial system startup and commissioning to supplement (not replace) commissioning agent reports.
4. Prepare quarterly reports summarizing faults detected and KPIs, including recommended corrective action.

I. Training:

1. Train Owner sufficiently to use software without need for external support.

2.12 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network, and vice versa, where applicable.

2. Write to all writable object properties on non-BACnet network from BACnet network, and vice versa, where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet, and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs in accordance with ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media with ability to modify, download, backup, and restore gateway configuration.

2.13 ASHRAE 135 PROTOCOL ANALYZER

A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.

B. Include the following minimum capabilities:

1. Capture and store to a file data traffic on all network levels.
2. Measure bandwidth usage.
3. Filtering options with ability to ignore select traffic.

2.14 DDC CONTROLLERS

A. DDC system consisting of a combination of network controllers, programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.

C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware suitable for anticipated ambient conditions.
2. Controllers located in conditioned space rated for operation at 32 to 120 deg F.
3. Controllers located outdoors and in unconditioned space rated for operation at -40 to 150 deg F.

F. Power and Noise Immunity:

1. Operate controller at 90 to 110 percent of nominal voltage rating and perform an orderly shutdown below 80 percent of nominal voltage.
2. Protect against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

    a. Network Controllers: 50 percent.
    b. Programmable Application Controllers: Not less than 70 percent.
    c. Application-Specific Controllers: Not less than 80 percent.

2. Memory for DDC controller's operating system and database are to include the following:

    a. Monitoring and control.
    b. Energy management, operation, and optimization applications.
    c. Alarm management.
    d. Historical trend data of all connected I/O points.
    e. Maintenance applications.
    f. Operator interfaces.
    g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:
    a. Minimum Spare I/O Points per Controller:

        1) AIs: Two.
        2) AOs: Two.
        3) BIs: Three.
        4) BOs: Three.
        5) Option to provide universal I/O to meet spare requirements.

2. Programmable Application Controllers:
    a. Minimum Spare I/O Points per Controller:

        1) AIs: Two.
        2) AOs: Two.
        3) BIs: Three.
        4) BOs: Three.
        5) Option to provide universal I/O to meet spare requirements.

3. Application-Specific Controllers:
    a. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: Two.
3) BIs: Two.
4) BOs: Two.
5) Option to provide universal I/O to meet spare requirements.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. I/O Point Interface:

1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
b. Compatible with, and field configurable to, sensor and transmitters installed.
c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
d. Signal conditioning including transient rejection for each AI.
e. Capable of being individually calibrated for zero and span.
f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
g. External conversion resistors are not permitted.

5. AOs:

a. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
b. Output signals range of 4 to 20 mA dc or 0 to 10 V dc as required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. Drift is to be not greater than 0.4 percent of range per year.
e. External conversion resistors are not permitted.

6. BIs:

    a. Accept contact closures and ignore transients of less than 5 ms duration.
    b. Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
    c. Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
    d. Sense "dry contact" closure without external power (other than that provided by controller) being applied.
    e. Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.

7. BOs:

    a. Include relay contact closures or triac outputs for momentary and maintained operation of output devices.

        1) Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.
        2) Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.
        3) Minimum contact rating to be 1 A at 24 V ac.
        4) Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.

    b. Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
    c. BOs to be selectable for either normally open or normally closed operation.
    d. Include tristate outputs (two coordinated BOs) for control of three-point, floating-type electronic actuators without feedback.
    e. Limit use of three-point floating devices to VAV terminal unit control applications. Control algorithms to operate actuator to one end of its stroke once every 12 hours for verification of operator tracking.

2.15 NETWORK CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.
4. Share data between networked controllers and other network devices.

5. Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Include network controllers with a real-time clock.
7. Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.
8. Make controllers fully programmable.

B. Communication:

1. Network controllers communicate with other devices on DDC system Level 1 network.
2. Network controller to also perform routing if connected to network of programmable application controllers and application-specific controllers.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to desktop operator's workstation, portable operator's workstation, or mobile device.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least 72 hours.

2.16 PROGRAMMABLE APPLICATION CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Include controllers that perform scheduling with a real-time clock.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B. Communication:

1. Programmable application controllers are to communicate with other devices on network.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to desktop operator's workstation, portable operator's workstation, or mobile device.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.17 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment or system. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and continued control functions without being connected to network.
2. Share data between networked controllers and other network devices.

B. Communication: Application-specific controllers are to communicate with other application-specific controllers and devices on network, and to programmable application controllers and network controllers.

C. Operator Interface: Equip controllers with a service communications port for connection to desktop workstation, portable operator's workstation, or mobile device.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.18 CONTROLLER SOFTWARE

A. General:

1. Software applications are to reside and operate in controllers. Edit applications through operator workstations or mobile devices.
2. Identify I/O points by up to 30-character point name and up to 16-character point descriptor. Use same names throughout, including at operator workstations.
3. Execute control functions within controllers using DDC algorithms.
4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Secure operator access using individual security passwords and usernames.
2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
3. Record operator log-on and log-off attempts.
4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.
d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Place schedules on scheduling calendar with ability to repeated each year.
c. Operator able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Include operator with a method of grouping together equipment based on function and location.
3. Include groups that may be for use in scheduling and other applications.

E. Binary Alarms:

1. Set each binary point to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Provide each analog object with both high and low alarm limits.
2. Include capability to automatically and manually disable alarming.

G. Alarm Reporting:

1. Include ability for operators to determine action to be taken in event of an alarm.
2. Route alarms to appropriate operator workstations based on time and other conditions.
3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.

H. Remote Communication:

1. Include ability for system to notify operators by phone message, text message, and email in event of an alarm.

I. Electric Power Demand Limiting:

1. Monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
2. Predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Accomplish demand reduction by the following means:

    a. Reset air-handling-unit supply temperature set points.
    b. Reset space temperature set points.
    c. De-energize equipment based on priority.

4. Base demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables on the means by which electric power service provider computes demand charges.

5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:

    a. Addition and deletion of loads controlled.
    b. Changes in demand intervals.
    c. Changes in demand limit for meter(s).
    d. Maximum shutoff time for equipment.
    e. Minimum shutoff time for equipment.
    f. Select rotational or sequential shedding and restoring.
    g. Shed and restore priority.

7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly, and annual basis:

    a. Total electric consumption.
    b. Peak demand.
    c. Date and time of peak demand.
    d. Daily peak demand.

J. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:

1. Support any of the following control loops, as applicable to control required:

    a. Two-position (on/off, open/close, slow/fast) control.
    b. Proportional control.
    c. Proportional plus integral (PI) control.
    d. Proportional plus integral plus derivative (PID) control.

        1) Include PID algorithms with direct or reverse action and anti-windup.
        2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
        3) Make controlled variable, set point, and PID gains operator-selectable.

    e. Adaptive (automatic tuning).

M. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.

N. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include algorithm that calculates a sliding-window average (rolling average). Make algorithm flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include algorithm that calculates a fixed-window average. Use a digital input signal to define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:

1. Protect BO points from short cycling.
2. Feature to allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. Assign a high run-time alarm, if required, by operator.

2.19 ENCLOSURES

A. General:

1. House each controller and associated control accessories in an enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
2. Do not house more than one controller in single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Individual, wall-mounted, single-door enclosures maximum of 36 inches wide and 60 inches high.
5. Individual, wall-mounted, double-door enclosures maximum of 60 inches wide and 60 inches high.
6. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
7. Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door.

B. Internal Arrangement:

1. Arrange internal layout of enclosure to group and protect electric, and electronic components associated with controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 20 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install maximum of two wires on each side of terminal.
9. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/4-inch- high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
14. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Cooper B-line; brand of Eaton, Electrical Sector.
    b. Hammond Mfg. Co. Inc.
    c. Hoffman; brand of nVent Electrical plc.
    d. Saginaw Control and Engineering.
2. NRTL listed in accordance with UL 50 or UL 50E.
3. Construct enclosure of steel, not less than the following:

    a. Enclosure Size Less Than 24 Inches: 0.067 inch thick.
    b. Enclosure Size 24 Inches and Larger: 0.093 inch thick.

4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior Color: Manufacturer's standard.
    b. Interior Color: Manufacturer's standard.

5. Hinged door full size of front face of enclosure and supported using the following:

    a. Enclosures Sizes Less Than 36 Inches Tall: Multiple butt hinges.
    b. Enclosures Sizes 36 Inches Tall and Larger: Continuous piano hinges.

6. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size Less Than 24 Inches: Solid steel, 0.053 inch thick.
    b. Size 24 Inches and Larger: Solid steel, 0.093 inch thick.

7. Internal panel mounting hardware, grounding hardware, and sealing washers.
8. Grounding stud on enclosure body.
9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall-Mounted, NEMA 250, Types 4 and 12:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Cooper B-line; brand of Eaton, Electrical Sector.
    b. Hammond Mfg. Co. Inc.
    c. Hoffman; brand of nVent Electrical plc.
    d. Saginaw Control and Engineering.
2. NRTL listed in accordance with UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.

5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
6. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
7. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
8. Construct enclosure of steel, not less than the following:

    a. Size Less Than 24 Inches: 0.067 inch thick.
    b. Size 24 Inches and Larger: 0.067 inch thick.

9. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior Color: Manufacturer's standard.
    b. Interior Color: Manufacturer's standard.

10. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 Inches Tall: Two hinges.
    b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
    c. Sizes Larger Than 48 Inches Tall: Four hinges.

11. Double-door enclosures with overlapping door design to include unobstructed full-width access.

    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

12. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size Less Than 24 Inches: Solid steel, 0.053 inch thick.
    b. Size 24 Inches and Larger: Solid steel, 0.093 inch thick.

13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
14. Grounding stud on enclosure body.
15. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X-SS:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Crouse-Hinds; brand of Eaton, Electrical Sector.
    b. Hammond Mfg. Co. Inc.
    c. Hoffman; brand of nVent Electrical plc.
    d. Saginaw Control and Engineering.

2. NRTL listed in accordance with UL 508A.

3. Seams and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Construct enclosure of Type 304 stainless steel, not less than the following:

    a. Size Less Than 24 Inches: 0.053 inch thick.
    b. Size 24 Inches and Larger: 0.067 inch thick.

6. Outside body and door of enclosure with brushed No. 4 finish.
7. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 Inches Tall: Two hinges.
    b. Sizes between 24 Inchesthrough 48 Inches Tall: Three hinges.
    c. Sizes Larger Than 48 Inches Tall: Four hinges.
8. Removable internal panel of 0.093-inch stainless steel.
9. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
10. Install corrosion-resistant polyester vent drain in a stainless steel sleeve at bottom of enclosure.
11. Include enclosure with stainless steel mounting brackets.

G. Accessories:

1. Electric Heater:

    a. Aluminum housing with brushed finish.
    b. Thermostatic control with adjustable set point from 0 to 100 deg F.
    c. Capacity: 100, 200, 400, and 800 W, as required by application.
    d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

2. Ventilation Fans, Filtered Intake, and Exhaust Grilles:

    a. Number and size of fans, filters, and grilles, as required by application.
    b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
    c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
    d. Thermostatic control with adjustable set point from 32 to 140 deg F.
    e. Airflow Capacity at Zero Pressure:

        1) 4-Inch Fan: 100 cfm.
        2) 6-Inch Fan: 240 cfm.
        3) 10-Inch Fan: 560 cfm.

    f. Maximum operating temperature of 158 deg F.

g. 4-inch fan thermally protected and provided with permanently lubricated ball-bearings.
h. 6- and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
i. Dynamically balanced impellers molded from polycarbonate material.
j. Fan furnished with power cord and polarized plug for power connection.
k. Fan brackets, finger guards, and mounting hardware provided with fans to complete installation.
l. Removable Intake and Exhaust Grilles: ABS plastic, of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
m. Filters for NEMA 250, Type 1 Enclosures: Washable foam, of size to match intake grille.
n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of size to match intake grille.

3. Bar handle with keyed cylinder lock set.

2.20 RELAYS

A. General-Purpose Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allen Bradley; by Rockwell Automation.
b. Eaton.
c. IDEC Corporation.
d. Omron Americas.
e. Siemens Industry, Inc., Building Technologies Division.
f. Square D; Schneider Electric USA.

2. NRTL listed.
3. Heavy-duty, electromechanical type; rated for at least 10 A at 250 V ac and 60 Hz.
4. SPDT, DPDT, or three-pole double-throw, as required by control application.
5. Plug-in-style relay with 8-pin octal or multiblade plug for DPDT relays and 11-pin octal or multiblade plug for three-pole double-throw relays.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a clear transparent polycarbonate dust-tight cover.
8. Include LED indication and push-to-test button to test manual operation of relay without power on coil.
9. Performance:

a. Mechanical Life: At least 10 million cycles.
b. Electrical Life: At least 100,000 cycles at rated load.
c. Pickup Time: 15 ms or less.
d. Dropout Time: 10 ms or less.
e. Pull-in Voltage: 85 percent of rated voltage.

f. Dropout Voltage: 50 percent of nominal rated voltage.
g. Power Consumption: 2 VA or less.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

10. Equip relays with coil transient suppression to limit transients to non-damaging levels.
11. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
12. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

B. Multifunction Time-Delay Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allen Bradley; by Rockwell Automation.
b. Eaton.
c. IDEC Corporation.
d. Omron Americas.
e. Siemens Industry, Inc., Building Technologies Division.
f. Square D; Schneider Electric USA.

2. NRTL listed.
3. Continuous-duty type, rated for at least 10 A at 240 V ac and 60 Hz.
4. Relay with up to 8 programmable functions to provide on/off delay, interval, and recycle timing functions.
5. Plug-in-style relay with either multi-pin or blade plug.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a dust-tight cover.
8. Include knob and dial scale for alternative digital interface for setting delay time.
9. Visual Status Indication: Power "On" status.
10. Performance:

a. Mechanical Life: At least 10 million cycles.
b. Electrical Life: At least 100,000 cycles at rated load.
c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
d. Repeatability: Within 2 percent.
e. Recycle Time: 45 ms.
f. Minimum Pulse-Width Control: 50 ms.
g. Power Consumption: 5 VA or less.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

11. Equip relays with transient suppression to limit transients to non-damaging levels.
12. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
13. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

C. Latching Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allen Bradley; by Rockwell Automation.
    b. Eaton.
    c. IDEC Corporation.
    d. Omron Americas.
    e. Siemens Industry, Inc., Building Technologies Division.
    f. Square D; Schneider Electric USA.
2. NRTL listed.
3. Continuous-duty type, rated for at least 10 A at 250 V ac and 60 Hz.
4. SPDT, DPDT, or three-pole double-throw, as required by control application.
5. Plug-in-style relay with either multi-pin or blade plug.
6. Construct contacts of silver, silver alloy, or gold.
7. Enclose relay in a clear transparent polycarbonate dust-tight cover.
8. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA or less.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

D. Current Sensing Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton.
    b. Functional Devices Inc.
    c. NK Technologies.
    d. Square D; Schneider Electric USA.
2. NRTL listed.
3. Monitors ac current.
4. Independent adjustable controls for pickup and dropout current.
5. Energized when supply voltage is present and current is above pickup setting.

6. De-energizes when monitored current is below dropout current.
7. Dropout current is adjustable from 50 to 95 percent of pickup current.
8. Visual indication of contact status.
9. Include current transformer, if required for application.
10. House current sensing relay and current transformer if required in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors applications and NEMA 250, Type 4X for outdoor applications.

E. Combination On-Off Status Sensor and On-Off Control Relays:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Functional Devices Inc.
    b. Veris Industries.
2. Description:

    a. On-off control and on-off status indication in a single device.
    b. LED status indication of activated relay and current trigger.
    c. Closed-Open-Auto override switch located on the load side of relay.

3. Performance:

    a. Ambient Temperature: Minus 30 to 140 deg F.
    b. Voltage Rating: Single-phase loads rated for 300 V ac. Three-phase loads rated for 600 V ac.

4. Status Indication:

    a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
    b. Current Sensor Range: As required by application.
    c. Current Set Point: Fixed or adjustable, as required by application.
    d. Current Sensor Output:

        1) Solid-state, SPDT contact rated for 30 V ac and dc and for 0.4 A.
        2) Solid-state, SPDT contact rated for 120 V ac and 1.0 A.
        3) Analog, 0 to 5 or 10 V dc.
        4) Analog, 4 to 20 mA, loop powered.

5. Relay: SPDT, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, Type 12 enclosure for indoor applications; NEMA 250, Type 4X enclosure for outdoor applications.

2.21 ELECTRICAL POWER DEVICES

A. Control Transformers:

1. Sizing Criteria: Size control transformers for total connected load, plus additional 50 percent of connected load for future spare capacity.
2. Transformer Minimum Capacity: 100 VA.
3. Protection: Provide transformers with both primary and secondary fuses. Integral circuit breaker is acceptable in lieu of fuses.
4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

B. Power-Line Conditioners:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton.
    b. Emerson Electric Co., Automation Solutions.
    c. SolaHD; Emerson Electric Co., Automation Solutions.
2. General Power-Line Conditioner Requirements:

    a. Design to ensure maximum reliability, serviceability, and performance.
    b. Overall function of power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. Power-line conditioner is to provide isolated, regulated, transient, and noise-free sinusoidal power to loads served.

3. Standards: NRTL listed per UL 1012.
4. Performance:

    a. Single phase, continuous, 100 percent duty rated kVA/kW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
    b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.

        1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
        2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
        3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

    c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to maximum harmonic content of 5 percent.

d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero to 100 to zero percent.
e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when output is taken from no load to full-resistive load, or vice versa. Recovery from partial resistive load changes is corrected in a shorter period.
f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
h. Attenuate load-generated odd current harmonics 23 dB at the input.
i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.1 and IEEE C62.41.2.
k. Common-mode noise attenuation of 140 dB.
l. Transverse-mode noise attenuation of 120 dB.
m. With loss of input power for up to 16.6 ms, output sine wave remains at usable ac voltage levels.
n. Reliability of 200,000 hours' MTBF.
o. At full load, when measured at 1 m distance, audible noise is not to exceed 54 dB.
p. Approximately 92 percent efficient at full load.

5. Transformer Construction:

a. Ferroresonant, dry type, convection cooled, 600 V class. Transformer windings of Class H (220 deg C) insulated copper.
b. Use Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40 deg C ambient temperature.
c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
e. Configure transformer secondary in 240/120 V split with 208 V tap or straight 120 V, depending on power output size.
f. Electrically isolate the transformer secondary windings from primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
g. Include interface terminals for output power hot, neutral, and ground conductors.
h. Label leads, wires, and terminals to correspond with circuit wiring diagram.
i. Vacuum impregnate transformer with epoxy resin.

6. Cabinet Construction:

a. Design for panel or floor mounting.

b. NEMA 250, Type 12 enclosure for indoor applications. NEMA 250, Type 4X for outdoor applications.
c. Manufacture the cabinet from heavy gauge steel complying with UL 50 or UL 508A.
d. Include textured baked-on paint finish.

C. DC Power Supplies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Acopian Technical Company.
b. Emerson Electric Co., Automation Solutions.
c. IDEC Corporation.
d. Omron Americas.

2. Description: Linear or switched, regulated power supplies with ac input to multiple dc output(s).

a. Include both line and load regulation to ensure stable output.
b. To protect both power supply and load, include power supply with an automatic current limiting circuit.

3. Features:

a. Connection: Plug-in style suitable for mating with standard 8-pin octal socket. Include power supply with mating mounting socket.
b. Housing: Enclose circuitry in a housing.
c. Local Adjustment: Include screw adjustment on exterior of housing for dc voltage output.
d. Mounting: DIN rail.
e. Visual status indicator.

4. Performance:

a. Input Voltage: Nominally 120 V ac, 60 Hz.
b. Output Voltage: Nominally 24 V dc with plus or minus 1 V dc adjustment.
c. Output Current: Minimum 100 mA.
d. Load Regulation: Within 0.1 percent.
e. Line Regulation: Within 0.05 percent.
f. Stability: Within 0.1 percent of rated volts after warmup period.
g. Ripple: 1 mV rms.

2.22 PROCESS TUBING

A. Products in this article are intended for signals to instruments connected to liquid and steam systems.

B. Stainless Steel Tubing (for Process Tubing):

1. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, and free from scale.
2. Chemical and physical properties in accordance with ASTM A269/A269M.
3. Diameter, as required by application, of not less than nominal 3/8 inch.
4. Wall thickness, as required by application, but not less than 0.035 inch.
5. Furnish stainless steel tubing in 20 ft. straight random lengths.

C. Stainless Steel Tubing Connectors and Fittings (for Process Tubing) - Stainless Steel, Compression Type:
1. Connectors and fittings constructed from Type 316 stainless steel, with collets, flareless type.
2. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.
3. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.

2.23 CONTROL WIRE AND CABLE

A. Comply with requirements in Section 260523 “Control-Voltage Electrical Power Cables”

B. Comply with requirements in Section 271500 "Communications Horizontal Cabling”

2.24 RACEWAYS

A. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for electrical power raceways and boxes.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cables and optical fiber cables.

2.25 OPTICAL FIBER CABLE AND CONNECTORS

A. Comply with requirements in Section 271323 "Communications Optical Fiber Backbone Cabling" for optical fiber backbone cabling and connectors.

B. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber horizontal cabling and connectors.

2.26 ACCESSORIES

A. Control Damper Blade Limit Switches:

1. Application: Sense positive open and/or closed position of damper blades.

2. NEMA 250, Type 13, oiltight construction. Install in instrument enclosure where required for additional environmental protection.
3. Arrange for mounting application, and to prevent "over-center" operation.

2.27 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Laminated acrylic or melamine plastic sign bearing unique identification.

    a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size as follows:

    a. Servers: Minimum of 0.5 inch high.
    b. DDC Controllers: Minimum of 0.5 inch high.
    c. Gateways: Minimum of 0.5 inch high.
    d. Enclosures: Minimum of 0.5 inch high.
    e. Electrical Power Devices: Minimum of 0.25 inch high.
    f. Accessories: Minimum of 0.25 inch high.
    g. Instruments: Minimum of 0.25 inch high.
    h. Control Damper and Valve Actuators: Minimum of 0.25 inch high.

3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
4. Fastened with drive pins.
5. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size at least 14-point type with white lettering on red background.
3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

2.28 SOURCE QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to evaluate the following in accordance with industry standards for each product, and to verify DDC system reliability specified in performance requirements:

1. DDC controllers.
2. Gateways.

B. Product(s) and material(s) will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system has communication interface with equipment having integral controls and having communication interface for remote monitoring or control.
2. Equipment to Be Connected:

a. Domestic water booster pumps specified in Section 221123.13 "Domestic-Water Packaged Booster Pumps."
b. Domestic water softeners specified in Section 223100 "Domestic Water Softeners."
c. Domestic water heaters specified in Section 223300 “Electric, Domestic-Water Heaters"
d. Boilers specified in Section 235216 "Condensing Boilers."
e. Boilers specified in Section 235239 "Fire-Tube Boilers."
f. Deaerator and condensate recievers specified in Section 235316 "Deaerators."
g. Continuous blowdown heat recovery system specified in Section 235405 “Continuous Blowdown Heat Recovery System.”Owner provided chillers and installed by contractor as specified in Section 236416 "Centrifugal Water Chillers."
h. Owner provided cooling towers and installed by contractor as specified in Section 236514.14 "Open-Circuit, Induced-Draft, Crossflow Cooling Towers."
i. Computer-room air-conditioning units specified in Section 238123.11 "Small Capacity (6 Tons (21 kW) and Smaller), Computer-Room Air-Conditioners, Floor-Mounted Units."
j. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."
k. Owner provided diesel emergency engine generators and installed by contractor as specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."
l. UPS specified in Section 263353 "Static Uninterruptible Power Supply."
m. Refrigerant monitoring specified in Section 230923.16 "Gas Instruments."

B. Communication Interface to Other Building Systems:

1. DDC system communicates with systems having communication interface.
2. Systems to Be Connected:

a. Elevators specified in Section 142100 "Electric Traction Elevators."
b. Automated water treatment systems specified in Section 232533 “HVAC Makeup-Water Filtration Equipment."
c. Power monitoring specified in Section 260913 "Electrical Power Monitoring."
d. Automation Integration Network specified in Division 25 “Integrated Automation.”
e. Lighting controls specified in Section 260923 " Lighting Control Devices."
f. Fire-alarm system specified in Section 284621.11 "Addressable Fire-Alarm Systems."
g. Access controls specified in Section 281300 "Access Control System Software and Database Management."

3.3 PREINSTALLATION INTEGRATION TESTING

A. Perform the following pretesting of other systems and equipment integration with DDC system before field installation:

1. Test all communications in a controlled environment to ensure connectivity.
2. Load software and demonstrate functional compliance with each control sequence of operation indicated.
3. Using simulation, demonstrate compliance with sequences of operation and other requirements indicated including, but not limited to, the following:

    a. HVAC equipment controlled through DDC system, such as boilers and related systems, chillers and related systems, pumps, and air-handling units.
    b. Equipment faults and system recovery with fault annunciation.
    c. Analog and Boolean value alarming and annunciation.

4. Develop a method for testing interfaces before deployment.
5. Submit documentation supporting compliance upon request.

3.4 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. Control dampers, which are specified in Section 230923.12 "Control Dampers."
2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
3. Pressure sensors and switches, which are specified in Section 230923.23 "Pressure Instruments."
4. Temperature sensors and switches, which are specified in Section 230923.27 “Temperature Instruments."

B. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. Control valves, which are specified in Section 230923.11 "Control Valves."
2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."
3. Pipe-mounted and tank mounted, liquid and steam pressure sensors, switches, and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
4. Liquid and steam temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."

5. Pipe- and tank-mounted thermowells. Liquid and steam thermowells are specified in Section 230923.27 "Temperature Instruments."

3.5 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer.

1. Programmable application or application-specific controller.
2. Unit-mounted DDC control dampers and actuators, which are specified in Section 230923.12 "Control Dampers."
3. Unit-mounted airflow sensors, switches, and transmitters, which are specified in Section 230923.14 "Flow Instruments."
4. Unit-mounted pressure sensors, switches, and transmitters, which are specified in Section 230923.23 "Pressure Instruments."
5. Unit-mounted temperature sensors, switches, and transmitters. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
6. Relays.

B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.

1. Programmable application or application-specific controller with integrated electric damper actuator.

C. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.

1. Programmable application or application-specific controller.

3.6 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a 20kN force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for

concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Fastening Hardware:

1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.7 INSTALLATION OF WORKSTATIONS

A. Desktop Workstation Installation:

1. Install Owner-furnished workstation(s) at location(s) indicated on Drawings.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex, electrical power receptacle.
3. Install DDC system software on workstation(s) and verify that software functions properly.
4. Develop Project-specific graphics, trends, reports, logs, and historical database.

B. Portable Workstation Installation:

1. Install internet browser with connection capability to HTML based controls system interface.

C. Color Graphics Application:

1. Use system schematics indicated on Drawings as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.

5. Seek Owner input in graphics development once using graphics software.
6. Make final editing on-site with Owner's and Architect's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.8 INSTALLATION OF SERVERS

A. Install server(s) at location(s) indicated on Drawings.

B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed server location in Shop Drawings.

C. Install software indicated on server(s) and verify that software functions properly.

D. Develop Project-specific graphics, trends, reports, logs, and historical database.

E. Power servers through centralized UPS system.

3.9 INSTALLATION OF GATEWAYS

A. Install gateways if required for DDC system communication interface requirements indicated.

B. Test gateways to verify that communication interface functions properly.

3.10 INSTALLATION OF CONTROLLERS

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controllers with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor, except where dedicated controllers are installed at terminal units.

G. Application-Specific Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.11 INSTALLATION OF ENCLOSURES

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Controllers.
3. Electrical power devices.
4. Relays.
5. Accessories.
6. Instruments.
7. Actuators.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use painted steel strut and hardware.

2. For NEMA 250, Type 12 Enclosures: Use galvanized-steel strut and hardware.
3. For NEMA 250, Type 4X Enclosures and Enclosures Located Outdoors: Use stainless steel strut and hardware.
4. Install plastic caps on exposed cut edges of strut.

C. Align top of adjacent enclosures.

D. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireways used for application are to have protection equal to NEMA 250 rating of connected enclosures.

3.12 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.13 INSTALLATION OF IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install laminated acrylic or melamine plastic signs with unique identification on face for each of the following:

1. Server.
2. Gateway.
3. Protocol analyzer.
4. DDC controller.
5. Enclosure.
6. Electrical power device.
7. Accessory.

C. Install unique instrument identification for each instrument connected to DDC controller.

D. Install unique identification for each control damper and valve actuator connected to DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

1. Permanently attach to equipment that can be automatically started by DDC control system.
2. Locate where highly visible near power service entry points.

3.14 INSTALLATION OF NETWORKS

A. Install optical fiber cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds 300 yards:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

B. Install balanced twisted pair or optical fiber cable when connecting between the following network devices:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

C. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:
1. Gateways and network controllers or programmable application controllers.
2. Programmable application controllers.
3. Application-specific controllers.

D. Install cable in continuous raceway.

3.15 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

a. Assign and document a MAC address unique to its network for every network device.
b. Ethernet Networks: Document MAC address assigned at its creation.
c. MS/TP Networks: Assign from 00 to 64.

2. Network Numbering:

a. Assign unique numbers to each new network.
b. Provide ability for changing network number through device switches or operator interface.
c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

a. Assign unique device object identifier property numbers or device instances for each device network.
b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN is to support up to 4,194,302 unique devices.

4. Device Object Name Property Text: (Naming convention described below is a temporary place holder. This convention is being further developed with IUH and will be updated in future revisions.)

a. Device object name property field to support 32 minimum printable characters.
b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field is to support 32 minimum printable characters.
b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."
2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to Drawings indicated.
b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

3.16 INSTALLATION OF PROCESS TUBING

A. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:

1. Meters.
2. Sensors.
3. Switches.
4. Transmitters.

B. Support tubing in accordance with MSS SP-58, but at intervals no more than 60 inches apart.

C. Install minimum NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install bushings where required.

D. Make smooth tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.

E. Support tubing independent of other trades.

F. Route tubing parallel to and at right angles to building construction.

G. Install tubing concealed in areas with ceilings.

H. Install dirt leg with an isolation valve and threaded plug-in drain valve at each connection to a transmitter and switch.

I. Insulate process piping and tubing connected to hot water and steam systems for personnel protection if surface temperature exceeds 120 deg F. Only insulate piping and tubing within maintenance personnel reach from floor, platform, or catwalk.

J. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with single wrap of PTFE tape.

K. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce possibility of galling.

L. Do not make tubing connections to a fitting before completing makeup of connection.

M. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.

N. Do not install fittings close to a bend. Straight length of tubing, not deformed by bending, is required for proper connection.

O. Align tubing with fitting when installed. Avoid springing tube into position.

P. Install tubing with extreme care to keep foreign matter out of system. Plug open tubing ends to keep out dust, dirt, and moisture.

Q. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.

R. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within 76 inches above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

S. Identify above-grade process tubing as follows:

1. Every 50 ft. of straight run.
2. At least once for each branch within 36 inches of main tee.
3. Near each change in direction.
4. Within 36 inches of each ceiling, floor, roof, and wall penetration.
5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
6. Near each isolation valve.
7. Mark each instrument tube connection with a number-coded identification. Each unique tube is to have same unique number at instrument connection and termination at opposite end of tube.

T. Process Tubing Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:

    a. Process connection.
    b. Inlet to each instrument including, sensors, transmitters, switches, gauges, and other control devices.

3. Locate valves to be readily accessible from floor.
4. Install needle valves for isolation and throttling applications.

3.17 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

5. Terminate wiring in a junction box.

    a. Clamp cable over jacket in a junction box.
    b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.

6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.
9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section 260533 "Raceway and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.18 INSTALLATION OF OPTICAL FIBER CABLE SYSTEMS

A. Comply with installation requirements in Section 271323 "Communications Optical Fiber Backbone Cabling."

B. Comply with installation requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

3.19 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Optical Fiber Cable Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. At a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question

condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.

4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Perform testing according to test plan supplied by DDC system manufacturer. Correct defective Work or material and retest. At a minimum, final testing for cable system, including spare cable, to verify compliance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use optical fiber time-domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.20 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

E. Control Damper Checkout:
1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment are secure.
5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

F. Control Valve Checkout:
1. Verify that control valves are installed correctly for flow direction.
2. Verify that valve body attachment is properly secured and sealed.
3. Verify that valve actuator and linkage attachment are secure.
4. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
5. Verify that valve ball, disc, or plug travel is unobstructed.
6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments, verify the following:

    a. Sensing element type and proper material.
    b. Length and insertion.

3.21 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.

F. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.

G. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.

H. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.

I. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

J. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

K. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
3. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

L. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Meters: Check meters at zero, 50, and 100 percent of Project design values.

N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

O. Switches: Calibrate switches to make or break contact at set points indicated.

P. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.22 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase, and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to backup power source.
6. If applicable, verify that power conditioning units are installed.

B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.23 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify that operation is stable and accurate.
4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.
10. Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.24 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed Pretest Checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting, and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power and loss of signal.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power and loss of signal.
18. Meter, sensor, and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit validation Test Plan including test procedures for performance validation tests.
2. Address all specified functions of DDC system and sequences of operation in Test Plan.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.

4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include Test Checklist to be used to check and initial that each test has been successfully completed.
6. Submit Test Plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.

        1) Identify I/O points for future reference.
        2) Simulate abnormal conditions to demonstrate proper function of safety devices.
        3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. 24 hours after initial validation test, do as follows:

    a. Re-check I/O points that required corrections during initial test.
    b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. 24 Hours after second validation test, do as follows:

    a. Re-check I/O points that required corrections during second test.
    b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate HLC.

    a. Heavy load to be occurrence of 50 percent of total connected binary COV, one-half of which represents "alarm" condition, and 50 percent of total

connected analog COV, one-half of which represents "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:

    a. Reaction to COV and alarm conditions during HLC.
    b. Ability to update DDC system database during HLC.

5. Passing test is contingent on the following:

    a. Alarm reporting at printer beginning no more than two seconds after initiation (time zero) of HLC.
    b. All alarms, both binary and analog, are reported and printed; none are lost.
    c. Compliance with response times specified.

6. Prepare and submit report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks are to use more than 70 percent of available bandwidth under normal and HLC operation.

3.25 FINAL REVIEW

A. Submit written request to Architect, Owner, Commissioning Agent, and Construction Manager when DDC system is ready for final review. State the following:

1. DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Upon receipt of written request for final review, Commissioning Agent and Construction Manager to start review within 14 business days and upon completion issue field report(s) documenting observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Compensation for Subsequent Reviews: Should more than two reviews be required, DDC system manufacturer and Installer to compensate entity/entities performing reviews for total costs (labor and expenses) associated with subsequent reviews. Estimated cost of each subsequent review to be submitted and approved by DDC system manufacturer and Installer before review.

E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

F. Part of DDC system final review shall to include demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration to include, but not be limited to, the following:

    a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
    b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 20 I/O points to be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
    c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
    d. Operation of randomly selected dampers and valves in normal-on, normal-off, and failed positions.
    e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
    f. Trends, summaries, logs, and reports set up for Project.
    g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
    h. Software's ability to communicate with controllers, operator workstations, and uploading and downloading of control programs.

i. Software's ability to edit control programs offline.
j. Data entry to show Project-specific customizing capability including parameter changes.
k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
l. Execution of digital and analog commands in graphic mode.
m. Spreadsheet and curve plot software and its integration with database.
n. Online user guide and help functions.
o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
p. System speed of response compared to requirements indicated.
q. For Each Network and Programmable Application Controller:

1) Memory: Programmed data, parameters, trend, and alarm history collected during normal operation are not to be lost during power failure.
2) Operator Interface: Ability to connect directly to each type of digital controller with portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
4) Electric Power: Ability to disconnect any controller safely from its power source.
5) Wiring Labels: Match control drawings.
6) Network Communication: Ability to locate controller's location on network and communication architecture matches Shop Drawings.
7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.

r. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.
2) Graphics are complete.
3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.

3) Set-Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by operator using workstation graphics, or by completing a field in menu with instructional text.
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:

    a) Display of network device status.
    b) Display of BACnet object information.
    c) Silencing devices transmitting erroneous data.
    d) Time synchronization.
    e) Remote device re-initialization.
    f) Backup and restore network device programming and master database(s).
    g) Configuration management of routers.

3.26 EXTENDED OPERATION TEST

A. Operate DDC system for operating period of [**14**] [**21**] [**28**] <**Insert number**> consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

B. Provide operator familiar with DDC system installed to man an operator workstation while on-site during eight hours of each normal business day occurring during operating period.

C. During operating period, DDC system to demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs,

trends, reports, specialized control algorithms, diagnostics, and other software indicated.

1. Correct defects of hardware and software when they occur.

D. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
2. Downtime is when any I/O point in DDC system is unable to fulfill its required function.
3. Calculate downtime as elapsed time between detected point failure as confirmed by operator, and time point is restored to service.
4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation is to be 0.5 hours.
5. Log downtime in hours to nearest 0.1 hour.
6. Power outages do not count as downtime, but do suspend test hours unless systems are provided with UPS and served through a backup power source.
7. Hardware or software failures caused by power outages do count as downtime.

E. During operating period, log downtime and operational problems are encountered.

1. Identify source of problem.
2. Provide written description of corrective action taken.
3. Record duration of downtime.
4. Maintain log showing the following:

    a. Time of occurrence.
    b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
    c. Downtime for each failed I/O point.
    d. Running total of downtime and total time of I/O point after each problem has been restored.

5. Make log available to Owner for review at any time.

F. For DDC system to pass extended operation test, total downtime is limited to 1 percent of total point-hours during operating period.

1. If DDC system testing results fail to comply with minimum requirements of passing at end of operating period indicated, extend operating period one consecutive day at a time until DDC system passes requirement.

G. Base evaluation of DDC system passing test on the following calculation:

1. Count downtime on point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.

2. One point-hour of downtime is one I/O point down for one hour. For example, three I/O points down for five hours is total of 15 point-hours of downtime. Four points down for one-half hour is two point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test for DDC system with 1000 total I/O points (combined analog and binary) and passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

H. Prepare test and inspection reports.

3.27 ADJUSTING

A. Occupancy Adjustments: When requested within 24 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to eight visits to Project during other-than-normal occupancy hours for this purpose.

3.28 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, verify that maintenance service includes 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.29 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for one year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

1. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.30 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:
   a. Stagger training over multiple training classes to accommodate Owner's requirements. All training to occur before end of warranty period.

C. Training Schedule:
1. Schedule training to provide Owner with at least 20 business days of notice in advance of training.
2. Training to occur within normal business hours at mutually agreed on time. Unless otherwise agreed to, training to occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session to be split in half with 15-minute break between sessions. Morning and afternoon sessions to be separated by 60-minute lunch period. Training, including breaks and excluding lunch period, are not to exceed eight hours per day.
3. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number, and email address.
2. Provide preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Include preprinted sign-in sheet with training session number, date and time, instructor name, phone number, email address, and brief description of content to be covered during session. List attendees with columns for name, phone number, and email address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an email with attachment of scanned copy (PDF) of circulated sign-in sheet for each session..

E. Training Attendee Headcount:

1. Plan in advance of training for five attendees.
2. Make allowance for Owner to add up to two attendee(s) at time of training.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F. Attendee Training Manuals:

1. Provide each attendee with color hard copy of all training materials and visual presentations.
2. Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials.

G. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Use instructors who have provided not less than five years of instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

H. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

    a. Daily operators.
    b. Advanced operators.
    c. System managers and administrators.

2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions to ensure DDC system security.

I. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Include in outline a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session, and synopses for each lesson planned.

J. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
2. Provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.

4. Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.

K. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
5. Operating operator workstations, printers, and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports, and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:

a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

L. Training Content for Advanced Operators:

1. Making and changing workstation graphics.
2. Creating, deleting, and modifying alarms including annunciation and routing.
3. Creating, deleting, and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting, and modifying reports.
5. Creating, deleting, and modifying points.
6. Creating, deleting, and modifying programming including ability to edit control programs offline.
7. Creating, deleting, and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices, and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing, and repairing hardware.
15. Adjusting, calibrating, and replacing DDC system components.

M. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading, and offline archiving of all DDC system software and databases.

3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

END OF SECTION 230923

SECTION 230923.11 - CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Ball-style control valves.
2. Butterfly-style control valves.
3. Globe-style control valves.
4. Pressure-independent control valves.
5. Solenoid valves.
6. Self-contained temperature-regulating valves.
7. Electric and electronic control valve actuators.

B. Related Requirements:
1. Section 230923 "Direct Digital Control (DDC) System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.
3. Section 232216 “Steam and Condensate Heating Piping Specialties” for requirements that relate to components of the 125-psig steam and condensate system.

1.2 DEFINITIONS

A. Cv: Valve coefficient.

B. DDC: Direct digital control.

C. EPT: Ethylene-propylene terpolymer rubber.

D. HNBR: Hydrogenated nitrile butadiene rubber.

E. NBR: Nitrile butadiene rubber.

F. PEEK: Polyether Ether Ketone rubber.

G. PTFE: Polytetrafluoroethylene.

H. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

I. RTFE: Glass-fiber-reinforced PTFE.

J. TFM: A chemically modified PTFE.

1.3 ACTION SUBMITTALS

A. Product Data:
1. Ball-style control valves.
2. Butterfly-style control valves.
3. Globe-style control valves.
4. Pressure-independent control valves.
5. Solenoid valves.
6. Self-contained temperature-regulating valves.
7. Electric and electronic control valve actuators.
8. Pneumatic control valve actuators.

B. Product Data Submittals: For each product.
1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

C. Shop Drawings:
1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for pneumatic signal and main air tubing.

D. Delegated Design Submittals:
1. Schedule and design calculations for control valves and actuators, including the following:
a. Flow at project design and minimum flow conditions.
b. Pressure differential drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.

e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst-case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are indicated and coordinated with each other, using input from installers of the items involved:
1. Control valve installation location indicated in relationship to room, duct, pipe, and equipment.
2. Size and location of wall access panels for control valves installed behind walls.
3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control valves.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

D. Code Compliance: Comply with governing energy code.

E. Delegated Design: Engage a qualified professional, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

F. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.

G. Backup Power Source: Serve control valve actuators from a backup power source where associated with systems and equipment served by a backup power source.

H. Environmental Conditions: For actuators not available with integral enclosures complying with requirements indicated, house in protective secondary enclosures complying with requirements.

I. Selection Criteria:
   1. Suitable for operation throughout full range of system operating conditions encountered.
      a. Boiler Condensate Transfer: 0 to 200 psig; 35 to 210 deg F.
      b. Boiler Feedwater Makeup: 0 to 200 psig; 35 to 210 deg F.
      c. Chilled Water: 0-to 250 psig, 35 to 100 deg F.
      d. Condenser Water: 0 to 200 psig; 35-150 deg F.
      e. Heat Recovery: 0 to 200 psig; 35 to 200 deg F.
      f. Heating Hot Water: 0 to 200 psig; 35 to 250 deg F.
      g. High Pressure Steam 150 psig and 450 def F.
      h. High Pressure Steam Condensate. 150 psig and 450 deg F.
   2. Control Valve Leakage: FCI 70-2, Class IV or less leakage, unless otherwise indicated.
   3. Control Valve Pattern: Straight-through or Three-way, as indicated on Drawings.
   4. Control Valve Flow Characteristics, Unless Otherwise Indicated:
      a. Modulating, Two-Way Pattern: Equal percentage.
      b. Modulating Three-Way Pattern: Linear flow. Total flow through the valve to be constant regardless of the valve's position.
      c. Modulating Butterfly Valves:
         1) Three way valve Linear flow
         2) Two way valve Equal percentage.
   5. Fail-Safe Positions, Unless Otherwise Indicated:
      a. Boiler Condensate Transfer: Last position
      b. Boiler Feedwater Makeup: Last position
      c. Chilled Water: Last position.
      d. Condenser Water: Last position.
      e. Heat Recovery: Last position.
      f. Heating Hot Water: Last position.
      g. Steam: Last position.
   6. Stable Operation: Select control valves and actuators for stable operation throughout full range of operation, from design Cv at design flow to minimum Cv.
   7. Control Valve Styles:
      a. Hydronic Systems:
         1) Pipe Sizes NPS 2 (DN 50) and Smaller: Ball- or globe-style control valves.
         2) Pipe Sizes Larger than NPS 2 (DN 50): Ball- butterfly- or globe-style control valves.
      b. Steam Systems: Use ball- or globe-style control valves.

J. Sizing Criteria: Unless otherwise indicated, select control valve size using the following:
   1. ISA Standards:
      a. Control Valve Sizes and Flow Coefficients: ISA 75.01.01.

b. Control Valve Characteristics and Rangeability: ISA 75.11.01.

2. Correction Factors: Consider viscosity, flashing, and cavitation corrections when selecting control valves.
3. Ball-Style Control Valves: Select valve size with design Cv at design flow between 65 and 75 degrees of valve full open position and minimum Cv between 15 and 25 percent of open position.
4. Butterfly-Style Control Valves: Select valve size with design Cv at design flow between 65 and 75 degrees of valve full open position and minimum Cv between 15 and 25 percent of open position.
5. Globe-Style Control Valves: Select valve size to pass the design Cv at design flow with not more than 95 percent of stem travel.
6. Modulating Control Valves for Steam Systems
   a. Select sizing of control valves so that design flow rates do not exceed 90% wide-open Cv of valve.
   b. Select sizing of actuators so that shutoff force required to close valve completely is not greater than 90% of maximum design shutoff force of actuator.
   c. Actuators shall be equipped with feedback positioners.
7. Modulating Control Valves in Hydronic Systems:
   a. Select modulating control valve sizes at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow.
   b. Calculate control valve minimum Cv at 10 percent of control valve design flow, with a coincident pressure differential equal to the system design pump head.
   c.
8. Two-Position Valves: Select two-position control valves for full pipeline size.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Threaded Ends, Two Way:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Belimo Aircontrols (USA), Inc.
   b. Honeywell Building Solutions; Honeywell International, Inc.
   c. Johnson Controls, Inc.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Siemens Industry, Inc., Building Technologies Division.
2. Source Limitations: Obtain threaded end two-way ball valves from single manufacturer.
3. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Controllable Flow Range: 75 percent open.
   c. Flow Characteristic: Modified equal percentage.
   d. Leakage: FCI 70-2, Class VI or less.

e. Hydronic Pressure:
1) Rating for Sizes NPS 1-1/4 (DN 32) and Smaller: Nominal 600 psig.
2) Rating for Sizes NPS 1-1/2 through NPS 2 (DN 38 through DN 50): Nominal 400 psig.
3) Close-off Pressure: 250 psig.
4) Leak Test Pressure Differential (Maximum): 50 psig.
f. Hydronic Process Temperature Range: 0 to 250 deg F.
g. Saturated Steam Pressure: 150 psig .

4. Construction for Ball Valves with Threaded Ends, Two Way:
a. Size Range: NPS 1/2 to NPS 2.
b. Body: Cast bronze or carbon steel stainless steel.
c. End Connections: Female threaded (NPT) ends.
d. Ball: Stainless steel.
e. Ball Seats: Reinforced PTFE.
f. Stem and Stem Extension:
1) Material to match ball.
2) Blowout-proof design.
3) For valves installed in insulated piping systems, provide stem extension extending beyond OD of insulation.
4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
g. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

B. Ball Valves with Flanged Ends, Two Way:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Milwaukee Valve Company.
b. NIBCO INC.
c. Valve Solutions, Inc.
d. Fisher Vee-Ball.
2. Source Limitations: Obtain flanged end two-way ball valves from single manufacturer.
3. Performance:
a. Stem Action: Rotary, 0 to 90 degrees.
b. Controllable Flow Range: 75 percent open.
c. Flow Characteristic: Modified equal percentage.
d. Leakage: FCI 70-2, Class VI or less.
e. Hydronic Pressure:
1) Rating: ASME B16.34, Class 150 or 300 required by application.
2) Close-off Pressure: Equal to rating.
3) Leakage Test Pressure Differential (Maximum): 50 psig.

f. Hydronic Process Temperature Range: 0 to 250 deg F.
g. Saturated Steam Pressure:
1) Rating: Maximum 150 psig
2) Close-off Pressure: Equal to pressure rating.
3) Leakage Test Differential (Maximum): Equal to pressure rating..

4. Standards for Ball Valves with Flanged Ends, Two Way: ASME B16.34, MSS SP-72.
5. Features:
a. Full or standard port.
b. Replaceable ball, seat and stem packing.
c. Pressure equalized between body cavity and the line flow.
d. Mounting pad for actuator.
6. Construction:
a. Size Range: NPS 1/2 to NPS 12.
b. Body: Cast steel or stainless steel; two pieces.
c. End Connections: Flanged ends suitable for mating to ASME B16.5 flanges.
d. Ball: Stainless steel; vented.
e. Ball Seats: Reinforced PTFE.
f. Stem: Material to match ball; blowout-proof design.
g. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure.

C. Ball Valves with Threaded Ends, Three Way:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Belimo Aircontrols (USA), Inc.
b. Honeywell Building Solutions; Honeywell International, Inc.
c. Johnson Controls, Inc.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Siemens Industry, Inc., Building Technologies Division.
2. Source Limitations: Obtain threaded end three-way ball valves from single manufacturer.
3. Performance:
a. Stem Action: Rotary, 0 to 90 degrees.
b. Controllable Flow Range: 75 percent open.
c. Flow Characteristic: Modified linear flow.
d. Leakage: FCI 70-2, Class IV or less.
e. Hydronic Pressure:
1) Rating for Sizes NPS 1-1/4 (DN 32) and Smaller: Nominal 600 psig.
2) Rating for Sizes NPS 1-1/2 through NPS 2 (DN 38 through DN 50): Nominal 400 psig.
3) Close-off Pressure: 200 psig.
4) Pressure Differential (Test Maximum): 50 psig.

f. Hydronic Process Temperature Range: 0 to 250 deg F.

4. Construction:
   a. Size Range: NPS 1/2 to NPS 2.
   b. Body: Cast bronze or stainless steel.
   c. End Connections: Female threaded (NPT) ends.
   d. Ball: Stainless steel.
   e. Ball Seats: Reinforced PTFE.
   f. Stem and Stem Extension:
      1) Material to match ball.
      2) Blowout-proof design.
      3) For valves installed in insulated piping systems, provide stem extension extending beyond OD of insulation.
      4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
   g. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

D. Ball Valves with Characterized Disk and Threaded Ends, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Belimo Aircontrols (USA), Inc.
   b. Bray Commercial.
   c. Honeywell Building Solutions; Honeywell International, Inc.
   d. Johnson Controls, Inc.
   e. Siemens Industry, Inc., Building Technologies Division.
2. Source Limitations: Obtain two-way ball valves, with characterized disk and threaded ends, from single manufacturer.
3. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Controllable Flow Range: 75 percent open.
   c. Flow Characteristic: Equal percentage.
   d. Leakage: FCI 70-2, Class IV or less.
   e. Hydronic Pressure:
      1) Rating for Sizes NPS 1-1/4 (DN 32) and Smaller: Nominal 600 psig.
      2) Rating for Sizes NPS 1-1/2 through NPS 2 (DN 38 through DN 50): Nominal 400 psig.
      3) Close-off Pressure: 200 psig.
      4) Leakage Test Pressure Differential (Maximum): 50 psig.
   f. Hydronic Process Temperature Range: 0 to 250 deg F.
   g. Rangeability: 300 to 1.
4. Construction:

a. Size Range: NPS 1/2 to NPS 2.
b. Body: Cast bronze or forged brass with nickel plating.
c. End Connections: Female threaded (NPT) ends.
d. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
e. Ball Seats: Reinforced PTFE.
f. Characterizing Disk: Glass-filled PTFE, Noryl, polyphthalamide resin, Tefzel or stainless steel.
g. Stem and Stem Extension:
   1) Material to match ball.
   2) Blowout-proof design.
   3) For valves installed in insulated piping systems, provide stem extension extending beyond OD of insulation.
   4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

E. Ball Valves with Characterized Disk and Flanged Ends, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Belimo Aircontrols (USA), Inc.
   b. Bray Commercial.
   c. Honeywell Building Solutions; Honeywell International, Inc.
   d. Johnson Controls, Inc.
2. Source Limitations: Obtain two-way ball valves, with characterized disk and flanged ends, from single manufacturer.
3. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Controllable Flow Range: 75 percent open.
   c. Flow Characteristic: Equal percentage.
   d. Leakage: FCI 70-2, Class IV or less.
   e. Hydronic Pressure:
      1) Rating: In accordance with ASME B16.1, Class B.
      2) Close-off Pressure:
         a) Class 125: 175 psig.
         b) Class 250: 310 psig.
      3) Leakage Test Pressure Differential (Maximum): 50 psig.
   f. Hydronic Process Temperature Range: 0 to 250 deg F.
   g. Steam System:
      1) Rating: In accordance with ASME B16.34.
      2) Close-off Pressure:

a) Class 150: 150 psig.
b) Class 300: 300 psig.
3) Leakage Test Pressure Differential (Maximum): Equal to pressure rating.
h. Steam System Temperature Range: 0 to 450 deg F.
i. Rangeability: 300 to 1.
4. Construction:
a. Size Range: NPS 2-1/2 to NPS 6.
b. Body: Cast iron, Class B in accordance with ASME B16.1.
1) Steam System: Steel, in accordance with ASME B16.34.
c. End Connections: Flanged, Class 125 or 250 in accordance with ASME B16.1.
1) Steam System: Flanged, Class 150 or 300 in accordance with ASME B16.34.
d. Ball: Stainless steel.
e. Ball Seats: Reinforced PTFE.
f. Characterizing Disk: Stainless steel.
g. Stem and Stem Extension: Material to match ball; blowout-proof design.
h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

F. Ball Valves with Characterized Disk and Threaded Ends, Three Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Belimo Aircontrols (USA), Inc.
b. Honeywell Building Solutions; Honeywell International, Inc.
c. Johnson Controls, Inc.
d. Siemens Industry, Inc., Building Technologies Division.
2. Source Limitations: Obtain three-way ball valves, with characterized disk and threaded ends, from single manufacturer.
3. Performance:
a. Stem Action: Rotary, 0 to 90 degrees.
b. Controllable Flow Range: 75 percent open.
c. Flow Characteristics:
1) A-Port: Equal percentage.
2) B-Port: Modified for constant common port flow.
d. Leakage: FCI 70-2, Class IV or less for A-port; one percent for B-port.
e. Hydronic Pressure:
1) Rating for Sizes NPS 1 (DN 25) and Smaller: Nominal 600 psig.
2) Rating for Sizes NPS 1-1/4 through NPS 2 (DN 32 through DN 50): Nominal 400 psig.
3) Close-off Pressure: 200 psig.

4) Leakage Test Pressure Differential (Maximum): 50 psig.

f. Hydronic Process Temperature Range: 0 to 250 deg F.

g. Rangeability: 300 to 1.

4. Construction:

a. Size Range: NPS 1/2 to NPS 2.

b. Body: Cast bronze or forged brass with nickel plating.

c. End Connections: Female threaded (NPT) ends.

d. Ball: Chrome-plated brass or bronze or 300 series stainless steel.

e. Ball Seats: Reinforced PTFE.

f. Characterizing Disk: Glass-filled PTFE, Noryl, polyphthalamide resin, Tefzel or stainless steel.

g. Stem and Stem Extension:

1) Material to match ball.

2) Blowout-proof design.

3) For valves installed in insulated piping systems, provide stem extension extending beyond OD of insulation.

4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.

h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

G. Ball Valves with Segmented Ball, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Bray Commercial.

b. Fischer; Emerson Electric Co., Automation Solutions.

c. Flowserve Corporation.

d. NELES.

2. Source Limitations: Obtain two-way ball valves, with segmented ball, from single manufacturer.

3. Performance:

a. Stem Action: Rotary, 0 to 90 degrees.

b. Controllable Flow Range: 75 percent open.

c. Flow Characteristic: Equal percentage or modified equal percentage.

d. Leakage: FCI 70-2, Class VI.

e. Hydronic Pressure:

1) Rating: ASME B16.34, Class 150 or 300 as required by application.

2) Close-off Pressure: 250 psig.

3) Leakage Test Pressure Differential (Maximum): Approximately 1/3 inlet pressure.

f. Hydronic Process Temperature Rating: 0 to 250 deg F.

g. Saturated Steam Pressure:
1) Rating: Maximum 250 psig
2) Close-off Pressure:250 psig .
3) Differential (Maximum): 150 psig.
h. Rangeability: 300 to 1.
4. Standards: ASME B16.10, ASME B16.34.
5. Features:
a. Stem and ball pinned and welded.
b. Replaceable ball, seat and packing.
6. Construction:
a. Size Range: NPS 1 to NPS 24.
b. End Connections: Flanged ends suitable for mating to ASME B16.5 flanges. Female threaded (NPT) ends are also acceptable for valve sizes NPS 2 and smaller.
c. Face-to-Face Dimensions: ASME B16.10 or ISA S75.08.02.
d. Body: Cast carbon or stainless steel.
e. Ball: Stainless steel.
f. Seat: TFM or reinforced PTFE.
g. Stem: Stainless steel.
h. Stem Packing: PTFE V-rings.
i. Label each valve with following:
1) Manufacturer's name, model number, and serial number.
2) Body size.
3) Flow directional arrow.
4)

H. Ball Valves with Full Ball and Characterized V-Notch, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Bray Commercial.
b. Flo-Tite, Inc.
c. Flow-Tek Valves & Controls Inc.
d. Valve Solutions, Inc.
e. Neles.
2. Source Limitations: Obtain two-way ball valves, with full ball and characterized v-notch, from single manufacturer.
3. Performance:
a. Stem Action: Rotary, 0 to 90 degrees.
b. Controllable Flow Range: 80 percent open.
c. Flow Characteristic: Equal percentage or modified equal percentage.
d. Leakage: FCI 70-2, Class VI.
e. Hydronic Pressure:
1) Rating:

a) Sizes NPS 2 (DN 50) and Smaller: ASME B16.34, Class 300 or 600.
b) Larger Sizes: ASME B16.34, Class 150 or 300 as required by application.

2) Close-off Pressure: Equal to rating.
3) Leakage Test Pressure Differential (Maximum): Approximately 1/3 inlet pressure.

f. Hydronic Process Temperature Rating: 0 to 250 deg F.
g. Saturated Steam Pressure:
1) Rating: Maximum 150 psig
2) Close-off Pressure: Equal to pressure rating at maximum temperature.
3) Differential (Maximum): 150 psig.
h. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.

4. Standards: ASME B16.34, MSS SP-72.
5. Features:
a. Full or standard port.
b. Replaceable ball, seat, shaft bushings, and packing.
c. Pressure equalized between body cavity and the line flow.
d. Universal mounting pad complying with ISO 5211 for actuator mounting.
6. Construction:
a. Size Range: NPS 1/2 to NPS 12.
b. Sizes NPS 2 (DN 50) and Smaller:
1) End Connections: Female threaded (NPT) ends complying with ASME B1.20.1 or flanged ends suitable for mating to ASME B16.5 flanges.
2) Stem Seals: Live-loaded, self-adjusting, primary and secondary sealing using belleville washers.
a) Primary Seal: Combination of thrust washer and thrust washer protector.
b) Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
c. Sizes Larger than NPS 2 (DN 50):
1) Stem Seals: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.
a) Primary Seal: Combination of thrust washer and thrust washer protector.
b) Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
2) Flanged ends suitable for mating to ASME B16.5 flanges.
d. Face-to-Face Dimension: ASME B16.10 short or long pattern, or ISA S75.08.02.
e. Body: Carbon or stainless steel; two- or three-piece design.
f. Ball: Stainless steel.
g. Seat: Reinforced PTFE, TFM, PEEK.

h. Shaft: Stainless steel.

7. Label each valve with following:
   a. Manufacturer's name, model number, and serial number.
   b. Body size.
   c. Flow directional arrow.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Butterfly Valves with Resilient Seats, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Bray Commercial.
   b. Honeywell Building Solutions; Honeywell International, Inc.
   c. Johnson Controls, Inc.
   d. Keystone; Emerson Electric Co., Automation Solutions.
   e. Siemens Industry, Inc., Building Technologies Division.
   f. Neles .

2. Source Limitations: Obtain two-way butterfly valves, with resilient seats, from single manufacturer.
3. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Flow Characteristic: Linear or modified equal percentage.
   c. Leakage: Bubble tight.
   d. Hydronic Pressure:
      1) Rating: Minimum 250 psig.
      2) Shutoff Pressure: Minimum 200 psig.
      3) Leakage Test Differential (Maximum): .
   e. Hydronic Process Temperature Range: 0 to 250 deg F.
4. Standards: MSS SP-67.
5. Features:
   a. Bidirectional, dead end service with downstream flange removed.
   b. Extended neck of body to accommodate up to 2-inch-thick insulation.
   c. Replaceable disc, shaft bearings/bushings and seat.
6. Construction:
   a. Size Range: NPS 2 to NPS 24
   b. Body: Cast iron or ductile iron; single flange, fully lugged and suitable for mating to ASME B16.5 flanges.
   c. Disc: Aluminum bronze nylon-coated ductile iron or stainless steel.
   d. Seat: Reinforced EPDM.
   e. Stem(s): Stainless steel.
   f. Stem Bushings: Reinforced PTFE.
   g. Corrosion-resistant nameplate indicating the following:

1) Manufacturer's name, model number, and serial number.
2) Body size.
3) Body and trim materials.
4) Flow arrow.

B. Butterfly Valves with Resilient Seats, Three Way:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bray Commercial.
   b. Honeywell Building Solutions; Honeywell International, Inc.
   c. Johnson Controls, Inc.
   d. Siemens Industry, Inc., Building Technologies Division.
   e. Valve Solutions, Inc.
   f. Neles
2. Source Limitations: Obtain three-way butterfly valves, with resilient seats, from single manufacturer.
3. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
4. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Flow Characteristic: Linear or modified equal percentage.
   c. Leakage: Bubble tight.
   d. Hydronic Pressure:
      1) Rating: Minimum 250 psig.
      2) Close-off Pressure: Minimum 250 psig.
      3) Leakage Test Differential (Maximum): equal to close off pressure.
   e. Hydronic Process Temperature Range: 0 to 225 deg F.
5. Standards: MSS SP-67.
6. Features:
   a. Bidirectional service.
   b. Extended neck of body to accommodate up to 2-inch-thick insulation.
   c. Replaceable disc, shaft bearings/bushings and seat.
7. Construction:
   a. Size Range: NPS 2 to NPS 24
   b. Body: Cast iron or ductile iron; single flange, fully lugged and suitable for mating to ASME B16.5 flanges.
   c. Disc: Aluminum bronze Nylon-coated ductile iron or stainless steel.
   d. Stem(s): Stainless steel.
   e. Seat: Reinforced EPDM.
   f. Stem Bearings/Bushings: Reinforced PTFE.
   g. Corrosion-resistant nameplate indicating the following:
      1) Manufacturer's name, model number, and serial number.
      2) Body size.
      3) Body and trim materials.

4) Flow arrow.

C. High-Performance Butterfly Valves, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Bray Commercial.
   b. Fischer; Emerson Electric Co., Automation Solutions.
   c. Flowserve Corporation.
   d. Keystone; Emerson Electric Co., Automation Solutions.
   e. Valve Solutions, Inc.
   f. Neles

2. Source Limitations: Obtain two-way high-performance butterfly valves from single manufacturer.
3. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Flow Characteristic: Linear or modified equal percentage.
   c. Leakage: FCI 70-2, Class VI.
   d. Hydronic Pressure:
      1) Rating: ASME B16.34, Class 150 or 300 as required by application.
      2) Close-off Pressure: Equal to rating.
      3) Pressure Differential (Maximum): equal to rating>.
   e. Hydronic Process Temperature Rating: 0 to 250 deg F.
   f. Saturated Steam Pressure
      1) Rating: Maximum 150 psig
      2) Close-off Pressure: Equal to pressure rating.
      3) Leakage Test Differential (Maximum): equal to rating.
   g. Rangeability: 100 to 1.
4. Standards: ASME B16.34, MSS SP-68.
5. Features:
   a. Bidirectional, end-of-line service with downstream flange removed.
   b. Extended neck of body to accommodate up to 2-inch-thick insulation.
   c. Replaceable seat, disc and shaft bearings/bushings.
6. Construction:
   a. Size Range: NPS 2-1/2 to NPS 36
   b. Body: Cast steel or stainless steel; single flange, fully lugged and suitable for mating to ASME B16.5 or ASME B16.47 flanges.
   c. Disc: Stainless steel.
   d. Seat: Reinforced PTFE with stainless steel retaining ring.
   e. Stem(s): Stainless steel.
   f. Stem Bearings: Stainless steel.
   g. Stem Packing: PTFE.
   h. Corrosion-resistant nameplate indicating the following:
      1) Manufacturer's name, model number, and serial number.

2) Body size.
3) Body and trim materials.
4) Body rating.
5) Arrow indicating direction of flow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Requirements:
1. Body Dimensions: Comply with ISA 75.08.01.
2. Field Service: Construct the valves to be serviceable from the top with replaceable seats and plugs.
3. Field-Interchangeable Trim:
a. Cage Guided Valves: Available with field-interchangeable trim for different valve flow characteristics, such as equal percentage, linear, and quick opening.
b. Industrial Valves NPS 1 and Larger: Available with reduced trim one nominal size smaller.
4. Nameplate: Corrosion-resistant, indicating the following:
a. Manufacturer's name, model number, and serial number.
b. Body and trim size.
c. Arrow indicating direction of flow.

B. Globe Valves NPS 2 (DN 50) and Smaller, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Belimo Aircontrols (USA), Inc.
b. Johnson Controls, Inc.
c. Siemens Industry, Inc., Building Technologies Division.
2. Source Limitations: Obtain two-way globe valves, NPS 2 and smaller, from single manufacturer.
3. Performance:
a. Stem Action: Linear stem travel.
b. Flow Characteristic: Equal percentage.
c. Leakage: FCI 70-2, Class IV for brass trim or 0.05 percent of maximum flow for stainless steel trim.
d. Hydronic Pressure:
1) Rating: In accordance with ASME B16.15, Class 250.
2) Close-off Pressure: Equal to pressure rating at maximum temperature.
3) Leakage Test Pressure Differential (Maximum): 50 psig.
e. Saturated Steam Pressure:
1) Rating: In accordance with ASME B16.15, Class 250.

2) Close-off Pressure: Equal to pressure rating at maximum temperature.
3) Pressure Differential (Maximum): 150 psig for control valves with stainless steel trim.

f. Ambient Operating Temperature: 35 to 150 deg F.
g. Process Temperature Range:
1) Hydronic: 35 to 248 deg F.
2) Steam: Temperature at saturated steam pressure.
h. Rangeability: 100 to 1.

4. Construction:
a. Size Range: NPS 1/2 to NPS 2.
b. Body: Cast bronze or forged brass; ASME B16.15, Class 250.
c. End Connections: Female NPT threaded ends, Unions with solder ends Unions with threaded ends.
d. Bonnet: Bronze or brass, threaded.
e. Plug: Top guided.
f. Brass Trim:
1) Packing: Self-adjusting Ethylene Propylene Rubber (EPR) rings or PTFE V-ring.
2) Plug: Brass.
3) Seat: Bronze or molded elastomeric disk.
4) Stem: Stainless steel.
g. Stainless Steel Trim:
1) Packing: PTFE V-ring.
2) Plug: Stainless steel.
3) Seat: Stainless steel.
4) Stem: Stainless steel.

C. Globe Valves NPS 2 (DN 50) and Smaller, Three Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Belimo Aircontrols (USA), Inc.
b. Johnson Controls, Inc.
c. Siemens Industry, Inc., Building Technologies Division.
2. Source Limitations: Obtain three-way globe valves, NPS 2 and smaller, from single manufacturer.
3. Performance:
a. Stem Action: Linear stem travel.
b. Flow Characteristic: Linear.
c. Leakage: FCI 70-2, Class IV for brass trim or 0.05 percent of maximum flow for stainless steel trim.
d. Hydronic Pressure:
1) Rating: In accordance with ASME B16.15, Class 250.

2) Close-off Pressure: Equal to pressure rating at maximum temperature.
3) Leakage Test Pressure Differential (Maximum): 50 psig.

e. Ambient Operating Temperature: 35 to 250 deg F.
f. Hydronic Process Temperature Range: 35 to 248 deg F.
g. Rangeability: 100 to 1.

4. Construction:
a. Size Range: NPS 1/2 to NPS 2.
b. Body: Cast bronze or forged brass; ASME B16.15, Class 250.
c. End Connections: Female NPT threaded ends, Unions with solder ends Unions with threaded ends.
d. Bonnet: Bronze or brass, threaded.
e. Plug: Top guided.
f. Brass Trim:
1) Packing: Self-adjusting Ethylene Propylene Rubber (EPR) rings or PTFE V-ring.
2) Plug: Brass
3) Seat: Bronze or molded elastomeric disk.
4) Stem: Stainless steel.

D. Globe Valves NPS 2-1/2 to NPS 6 (DN 65 to DN 150), Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Belimo Aircontrols (USA), Inc.
b. Bray Commercial.
c. Honeywell Building Solutions; Honeywell International, Inc.
d. Johnson Controls, Inc.
e. Siemens Industry, Inc., Building Technologies Division.
f. Spence

2. Source Limitations: Obtain two-way globe valves, NPS 2-1/2 to NPS 6, from single manufacturer.
3. Performance:
a. Stem Action: Linear stem travel.
b. Flow Characteristic: Equal percentage or linear as application requires.
1) Steam System: Equal percentage flow characteristic.
c. Leakage: FCI 70-2, Class IV 0.1 percent of maximum flow Insert leakage.
d. Hydronic Pressure:
1) Rating: In accordance with ASME B16.1, Class 125 or 250 as required by application.
2) Close-off Pressure: Equal to pressure rating.
3) Pressure Differential (Maximum): 50 psig.
e. Hydronic Process Temperature: 35 to 280 deg F.
f. Saturated Steam Pressure:

1) Rating: In accordance with ASME B16.1, Class 125 or 250 as required by application.
2) Close-off Pressure: Equal to pressure rating.
3) Leakage Test Pressure Differential (Maximum): 50 **psig**].

g. Ambient Operating Temperature: 0 to 150 deg F.
h. Rangeability: 100 to 1.

4. Construction:
a. Size Range: NPS 2-1/2 to NPS 6.
b. Body: Cast iron; ASME B16.1.
c. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
d. Bonnet: Cast iron; bolted.
e. Plug: Top or bottom guided.
f. Brass or Bronze Trim:
1) Packing: EPT rings or PTFE V-ring.
2) Plug: Brass or bronze.
3) Seat: Brass or bronze.
4) Stem: Stainless steel.
g. Stainless Steel Trim:
1) Packing: PTFE V-ring.
2) Plug: Stainless steel.
3) Seat: Stainless steel.
4) Stem: Stainless steel.

E. Globe Valves NPS 2-1/2 to NPS 6 (DN 65 to DN 150), Three Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Belimo Aircontrols (USA), Inc.
b. Bray Commercial.
c. Honeywell Building Solutions; Honeywell International, Inc.
d. Johnson Controls, Inc.
e. Siemens Industry, Inc., Building Technologies Division.

2. Source Limitations: Obtain three-way globe valves, NPS 2-1/2 to NPS 6, from single manufacturer.
3. Performance:
a. Stem Action: Linear stem travel.
b. Flow Characteristic: Linear.
c. Leakage: FCI 70-2, Class IV.
d. Hydronic Pressure:
1) Rating: In accordance with ASME B16.1, Class 125 or 250 as required by application.
2) Close-off Pressure: Equal to pressure rating.
3) Leakage Test Pressure Differential (Maximum): .
e. Hydronic Process Temperature: 35 to 280 deg F.

f. Ambient Operating Temperature: 0 to 150 deg F.
g. Rangeability: 100 to 1.

4. Construction:
a. Size Range: NPS 2-1/2 to NPS 6.
b. Body: Cast iron; ASME B16.1.
c. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
d. Bonnet: Cast iron; bolted.
e. Plug: Top or bottom guided.
f. Brass or Bronze Trim:
1) Packing: EPT rings or PTFE V-ring.
2) Plug: Brass or bronze.
3) Seat: Brass or bronze.
4) Stem: Stainless steel.
g. Stainless Steel Trim:
1) Packing: PTFE V-ring.
2) Plug: Stainless steel.
3) Seat: Stainless steel.
4) Stem: Stainless steel.

F. Industrial-Grade Globe Valves NPS 3/4 (DN 20) and Smaller, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Fischer; Emerson Electric Co., Automation Solutions.
b. Spence Engineering Company, Inc.
c. Spirax Sarco Limited.

2. Source Limitations: Obtain two-way industrial-grade globe valves, NPS 3/4 and smaller, from single manufacturer.
3. Performance:
a. Stem Action: Linear stem travel.
b. Flow Characteristic: Equal percentage.
c. Leakage: FCI 70-2, Class IV.
d. Hydronic Pressure:
1) Rating: In accordance with ASME B16.15, Class 250.
2) Close-off Pressure: Equal to pressure rating.
3) Leakage Test Pressure Differential (Maximum): 100 psig.
e. Hydronic Process Temperature Range: 0 to 400 deg F.
f. Saturated Steam Pressure:
1) Rating: In accordance with ASME B16.15, Class 250.
2) Close-off Pressure: Equal to pressure rating.
3) Pressure Differential (Maximum): 150 psig.
g. Ambient Operating Temperature: Minus 20 to 150 deg F.
h. Rangeability: 100 to 1.
4. Construction:

a. Size Range: NPS1/2 to NPS 3/4.
b. Body: Bronze.
c. End Connections: Female NPT threaded.
d. Bonnet: Bronze; screwed or bolted.
e. Packing: PTFE V-ring.
f. Plug: Top or cage guided; balanced or unbalanced.
g. Plug and Stem: Stainless steel.
h. Seat: Stainless steel with PTFE insert.

G. Industrial-Grade Globe Valves NPS 1 (DN 25) and Larger, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Fischer; Emerson Electric Co., Automation Solutions.
   b. Flowserve Corporation.
   c. Jordan Valve; Richards Industries Company.
   d. Spirax Sarco Limited.
2. Source Limitations: Obtain two-way industrial-grade globe valves from single manufacturer.
3. Performance:
   a. Stem Action: Linear stem travel.
   b. Flow Characteristic: Equal percentage.
   c. Leakage: FCI 70-2, Class IV.
   d. Hydronic Pressure:
      1) Rating for Cast-Iron Body Valves: In accordance with ASME B16.1, Class 125 or 250, as required by application.
      2) Rating for Cast-Steel and Stainless Steel Body Valves: In accordance with ASME B16.34, Class 150 or 300, as required by application.
      3) Close-off Pressure: Equal to pressure rating.
      4) Pressure Differential (Maximum): 100 psig.
   e. Hydronic Process Temperature: 0 to 450 deg F.
   f. Saturated Steam Pressure:
      1) Rating for Cast-Iron Valves: In accordance with ASME B16.1, Class 125 or 250, as required by application.
      2) Rating for Cast-Steel and Stainless Steel Valves: In accordance with ASME B16.34, Class 150 or 300, as required by application.
      3) Close-off Pressure: Equal to pressure rating.
      4) Leakage Test Pressure Differential (Maximum): 150 psig.
   g. Ambient Operating Temperature: Minus 20 to 150 deg F.
   h. Rangeability: 100 to 1.
4. Features:
   a. Interchangeable, restricted-capacity and full-size trim.
   b. Interchangeable, cage and plug styles for three different flow characteristics: equal percentage, linear and quick opening.

c. Trim options to prevent damage caused by cavitation or wire drawing where required by application.

5. Construction:
   a. Size Range: NPS 1 to NPS 30.
   b. Body: Cast iron carbon steel or stainless steel.
   c. End Connections:
      1) NPS 2 (DN 50) and Smaller: Female NPT threaded or flanged suitable for mating to ASME B16.5 flanges.
      2) NPS 2-1/2 (DN 65) and Larger: Raised face flanges suitable for mating to ASME B16.5 or ASME B16.47 flanges.
   d. Bonnet: Bolted, material to match body.
   e. Packing: PTFE V-ring.
   f. Plug: Cage guided and balanced.
   g. Plug, Seat, Cage, and Stem: Stainless steel plug and seat with hardened facing, stainless steel cage and stem.
   h. Stem: Thread and pin stem to plug; polished finish.

2.5 PRESSURE-INDEPENDENT CONTROL VALVES

A. Pressure-Independent Ball Valves NPS 2 (DN 50) and Smaller:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Belimo Aircontrols (USA), Inc.
   b. Bray Commercial.
   c. Griswold Controls, LLC.
   d. Honeywell Building Solutions; Honeywell International, Inc.
   e. Johnson Controls, Inc.

2. Source Limitations: Obtain pressure-independent ball valves, NPS 2 and smaller, from single manufacturer.
3. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Flow Characteristic: Equal percentage.
   c. Leakage: Zero.
   d. Hydronic Pressure Rating: 360 psig.
   e. Hydronic Close-off Pressure: 200 psig.
   f. Process Temperature Range: Between 35 to 250 deg F.
   g. Rangeability: 100 to 1.
4. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by one of the follow methods:
   a. Integral Mechanical Regulation: Maintains a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.

b. Integral Electronic Regulation: Electronic flow meter and control signal to maintain flow set point regardless of system pressure variations and modulates valve based on its measured true flow.
   1) Flow Measurement: Within 2 percent of actual reading.
   2) Flow Control: Within 5 percent of set point.
   3) Pressure Differential Range: 5 to 50 psig.

5. Construction:
   a. Body: Bronze or forged brass, nickel plated.
   b. End Connections: Female threaded (NPT) ends.
   c. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
   d. Diaphragm: HNBR or EPDM.
   e. Ball: Chrome-plated brass or stainless steel.
   f. Seats: RTFE.
   g. Stem and Stem Extension: Material to match ball; blowout-proof design.
   h. Stem Seal: RTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.

B. Pressure-Independent Ball Valves NPS 2-1/2 to NPS 6 (DN 65 to DN 150):

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Belimo Aircontrols (USA), Inc.
   b. Bray Commercial.

2. Source Limitations: Obtain pressure-independent ball valves NPS 2-1/2 to NPS 6 from single manufacturer.
3. Performance:
   a. Stem Action: Rotary, 0 to 90 degrees.
   b. Flow Characteristic: Equal percentage.
   c. Leakage: Zero.
   d. Hydronic Pressure Rating: In accordance with ASME B16.1, Class 125 or 250, as required by application.
   e. Hydronic Close-off Pressure:
      1) Class 125: 175 psig.
      2) Class 250: 310 psig.
   f. Process Temperature Range: Between 35 to 250 deg F.
   g. Rangeability: 100 to 1.
4. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by one of the follow methods:
   a. Integral Mechanical Regulation: Maintains a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.

b. Integral Electronic Regulation: Electronic flow meter and control signal to maintain flow set point regardless of system pressure variations and modulates valve based on its measured true flow.
   1) Flow Measurement: Within 2 percent of actual reading.
   2) Flow Control: Within 5 percent of set point.
   3) Pressure Differential Range: 5 to 50 psig.

5. Construction:
   a. Body: Cast iron; ASME B16.1.
   b. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
   c. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
   d. Ball: Stainless steel.
   e. Seats: RTFE.
   f. Stem and Stem Extension: Material to match ball; blowout-proof design.
   g. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.

C. Pressure-Independent Globe Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Bray Commercial.
   b. Danfoss, Inc.
   c. Flow Control Industries, Inc.
   d. Johnson Controls, Inc.
   e. Siemens Industry, Inc., Building Technologies Division.

2. Source Limitations: Obtain threaded end pressure-independent globe valves from single manufacturer.
3. Performance:
   a. Stem Action: Linear stem travel.
   b. Flow Characteristic: Equal percentage.
   c. Flow Control: Within 5 percent of set point.
   d. Leakage: FCI 70-2, Class IV.
   e. Hydronic Pressure Rating: 250 psig.
   f. Hydronic Close-off Pressure: 140 psig.
   g. Process Temperature Range: Between 35 to 240 deg F.
   h. Rangeability: 50 to 1.
4. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by integral mechanical regulation to maintain a constant pressure differential while operating within a pressure differential range of 5 to 60 psig.
5. Construction:
   a. Size Range: NPS 1/2 to NPS 2.
   b. Body: Bronze or forged brass.

c. End Connections: Female threaded (NPT) ends.
d. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
e. Diaphragm: HNBR or EPDM.
f. O-Rings: EPDM.
g. Plug: Brass or stainless steel.
h. Spring: Stainless steel.
i. Stem: Stainless steel.

D. Pressure-Independent Globe Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Bell & Gossett; a Xylem brand.
   b. Bray Commercial.
   c. Danfoss, Inc.
   d. Flow Control Industries, Inc.
   e. Honeywell Building Solutions; Honeywell International, Inc.
   f. Siemens Industry, Inc., Building Technologies Division.
2. Source Limitations: Obtain flanged end pressure-independent globe valves from single manufacturer.
3. Performance:
   a. Stem Action: Linear stem travel.
   b. Flow Characteristic: Equal percentage.
   c. Flow Control: Within 5 percent of set point.
   d. Leakage: FCI 70-2, Class IV.
   e. Hydronic Pressure Rating: 250 psig.
   f. Hydronic Close-off Pressure: 90 psig.
   g. Process Temperature Range: Between 35 to 240 deg F.
   h. Rangeability: 50 to 1.
4. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by integral mechanical regulation to maintain a constant pressure differential while operating within a pressure differential range of 5 to 60 psig.
5. Construction:
   a. Size Range: NPS 2-1/2 to NPS 10.
   b. Body: Cast iron or ductile iron.
   c. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
   d. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
   e. Diaphragm: HNBR or EPDM.
   f. O-Rings: EPDM.
   g. Plug: Brass or stainless steel.
   h. Spring: Stainless steel.
   i. Stem: Stainless steel.

2.6 SOLENOID VALVES

A. Brass and Bronze Solenoid Valves, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. ASCO; Emerson Electric Co., Automation Solutions.
   b. Danfoss, Inc.
   c. Parker (Parker Hannifin).
2. Source Limitations: Obtain two-way brass and bronze solenoid valves from single manufacturer.
3. Performance:
   a. Ambient Operating Temperature: 32 to 125 deg F.
   b. Leakage: Bubbletight.
   c. Hydronic Operating Pressure:
      1) Maximum: 200 psig 300 psig.
      2) Minimum Operating: 0 psig.
   d. Hydronic Process Temperature Range: 0 to 250 deg F.
   e. Saturated Steam Pressure: 125 psig.
   f. Speed of Response: Manufacturer's standard design or slow-closing design to reduce potential water hammer as required by application.
   g. Voltage: Coordinate with field power source.
4. Features:
   a. Action: Either normally open (open when de-energized) or normally closed (closed when de-energized), as required by the application.
   b. Operation: Direct-acting or pilot-operated diaphragm or piston, as required by the application.
   c. Override: Integral manual override.
5. Construction:
   a. Size Range: NPS 1/2 to NPS 2.
   b. Body: Brass or bronze.
   c. End Connections: Female threaded (NPT) ends.
   d. Discs and Seats: NBR, EPDM or PTFE.
   e. Orifice: Select size for performance required by application.
   f. Wetted Parts: Stainless steel.
   g. Coil: Copper.
   h. Coil Insulation: Class F or Class H.
   i. Solenoid Enclosure: NEMA 250, Type 4 or Type 4X.

B. Stainless Steel Solenoid Valves, Two Way:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. ASCO; Emerson Electric Co., Automation Solutions.
b. Danfoss, Inc.
c. Parker (Parker Hannifin).

2. Source Limitations: Obtain two-way stainless steel solenoid valves from single manufacturer.
3. Performance:
   a. Ambient Operating Temperature: 32 to 125 deg F.
   b. Leakage: Bubbletight.
   c. Hydronic Operating Pressure:
      1) Maximum: 200 psig or 300 psig as required by application
      2) Minimum Operating: 0 psig.
   d. Hydronic Process Temperature Range: 0 to 250 deg F.
   e. Saturated Steam Pressure: 125 psig.
   f. Speed of Response: Manufacturer's standard design or slow-closing design to reduce potential water hammer.
   g. Voltage: Coordinate with field power source.
4. Features:
   a. Action: Either normally open (open when de-energized) or normally closed (closed when de-energized), as required by the application.
   b. Operation: Direct-acting or pilot-operated diaphragm or piston, as required by the application.
   c. Override: Integral manual override.
5. Construction:
   a. Size Range: NPS 1/2 to NPS 2.
   b. Body: Stainless steel.
   c. End Connections: Female threaded (NPT) ends.
   d. Discs and Seats: NBR, EPDM, or PTFE.
   e. Orifice: Select size for performance required by application.
   f. Wetted Parts: Stainless steel.
   g. Coil: Silver.
   h. Coil Insulation: Class F or Class H.
   i. Solenoid Enclosure: NEMA 250, Type 4 or Type 4X.

2.7 SELF-CONTAINED TEMPERATURE-REGULATING VALVE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Jordan Valve; Richards Industries Company.
2. Spence Engineering Company, Inc.
3. Spirax Sarco Limited.

B. Source Limitations: Obtain self-contained temperature-regulating valves from single manufacturer.

C. Description:
1. Self-contained and self-operated temperature-regulating valve. Direct acting or reverse acting, as required by application.
2. Direct Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn closing the fail-safe open valve.
3. Reverse Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn opening the fail-safe closed valve.

D. Performance:
1. Leakage: Comply with FCI 70-2, Class IV.
2. Hydronic Pressure:
a. Rating: 200 psig.
b. Close-off: Equal to rating.
c. Differential: .
3. Hydronic Process Temperature Range: Match to applications of up to 0 to 250 deg F.
a. Drains from Hot Equipment to Sanitary Sewer System: 105 to 140 deg F.
b. <Insert description of application>.
4. Saturated Steam Pressure: 150 psig.
5. Operating Range: Control flow from between 5 to 100 percent of rated capacity.
6. Sizing: Size to pass the design flow required with not more than 95 percent of the stem lift while operating at design pressure.

E. Features:
1. Interchangeable trim for one size smaller.
2. <Insert feature>.

F. Construction:
1. Size Range: NPS 1/2 to NPS 2.
2. Body: Bronze carbon steel ductile iron or stainless steel.
3. End Connections: Female threaded (NPT) ends.
4. Trim: 300 series stainless steel.
5. Seats: 300 series stainless steel, PTFE.
6. Actuator Yoke: Aluminum, cast iron or carbon steel.
7. Capillary, Bulb, and Armor: Copper or 300 series stainless steel bulb and capillary with stainless steel armor.
8. Thermal Fill Material: Match to the temperature range.
9. Thermowell: Type 316 stainless steel thermowell sized to fit the bulb and pipe.

2.8 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Belimo Aircontrols (USA), Inc.

2. Bray Commercial.
3. Emerson/Fisher Controls
4. Flowserve Corporation.
5. Honeywell International Inc.
6. Keystone; Emerson Electric Co., Automation Solutions.
7. Mallard Controls
8. Milwaukee Valve Company.
9. NIBCO INC.
10. Samson Controls Inc.
11. Spence Engineering Company, Inc.
12. Spirax Sarco Limited.

B. Furnish control valves with factory-installed actuators from control valve manufacturer. Actuators manufactured by listed control valve manufacturers are acceptable subject to compliance with requirements.

C. Actuators for Control Valves in Hydronic Systems: Select actuators to close off against system pump shutoff head.

D. Actuators for Control Valves in Steam Systems: Select actuators to close off against 1.2 times steam design pressure.

E. Type: Motor operated, with or without gears, electric and electronic.

F. Voltage:
1. Voltage selection is delegated to professional designing control system. Use 24 V or 120 V as application requires.
2. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator to function properly within a range of 85 to 120 percent of nameplate voltage.

G. Construction:
1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Ground steel gears, oil immersed; shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains are to be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

H. Local Field Adjustment: Make spring-return actuators easily switchable from fail-safe open to fail-safe closed in the field without replacement.

I. Local Manual Override: Provide gear-type actuators with hand wheel for valves larger than 5 inches and an external manual adjustment mechanism for valves 5 inches and to allow manual positioning of the valve when the actuator is not powered.

J. Two-Position Actuators: Single direction, spring-return or reversing type.

K. Modulating Actuators:
1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:
   a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
   b. Proportional: Actuator drives proportionally to input signal, modulates throughout its angle of rotation, and is suitable for zero to 10 or 2 to 10 V dc and 4 to 20 mA signals.
   c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
   d. Programmable Multifunction:
      1) Control input, position feedback, and running time are to be factory or field programmable.
      2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
      3) Service data, including at a minimum, number of hours powered and number of hours in motion.

L. Position Feedback:
1. Equip two-position actuators with limit switches or other positive means of position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

M. Fail-Safe:
1. Where indicated, provide actuator to fail to an end position.
2. Internal spring-return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other nonmechanical forms of fail-safe operation are acceptable only where uniquely indicated.

N. Integral Overload Protection:
1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:
1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve stem without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.

3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

P. Temperature and Humidity:
1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range is to be from 5 to 95 percent relative humidity, noncondensing.

Q. Enclosure:
1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 or Type 4 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. NEMA 250, Type 7 or Type 9 for hazardous applications requiring explosion-proof construction.
5. Provide actuator enclosure with a heater and controller where required by application.

R. Stroke Time:
1. Select operating stroke time to be compatible with equipment and system operation**, and as follows:**
2. 2.For chilled water, and heating hot water AHU and VAV Box coil control valves.
   a. Operate valve from fully closed to fully open position within 60 seconds.
   b. Operate valve from fully open to fully closed position within 60 seconds.
   c. Move valve to fail-safe position within 15 seconds.
3. For chiller, boiler and cooling tower isolation control valves .
   a. Operate valve from fully closed to fully open position within 60 seconds.
   b. Operate valve from fully open to fully closed position within 60 seconds.
   c. Move valve to fail-safe position within 15 seconds.
4. For chiller, and cooling tower bypass control valves .
   a. Operate valve from fully closed to fully open position within 15 seconds.
   b. Operate valve from fully open to fully closed position within 15 seconds.
   c. Move valve to fail-safe position within 15 seconds.

S. Sound: Where actuators are located in tenant-occupied rooms with a room sound level criteria of NC-35 or lower, comply with the following sound levels:
1. Spring Return: 45dBA.
2. Nonspring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL VALVE APPLICATIONS

A. Control Valves:

1. See control valve schedule on drawings
1.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support control valves and actuators, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic event, wind, or others forces common to the application.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Seal penetrations made in fire-rated and acoustically rated assemblies.

F. Fastening Hardware:
1. Wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:
1. Use products that are suitable for environment to which they will be subjected.
2. Use Type 316 stainless steel tubing and fittings when in contact with a corrosive environment.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 CONTROL VALVES

A. Install pipe reducers for control valves smaller than line size. Position reducers as close to control valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Drain Valves:
1. Install drain valves in piping upstream and downstream of each control valve larger than NPS 2 >.
2. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold.

D. Test Plugs: Install pressure temperature test plugs in piping upstream and downstream of each control valve.

E. Three-Valve Bypass Manifold: install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing isolation valves in inlet and discharge piping of control valve and a manual throttling valve in bypass pipe.

1. Cooling tower blowdown valve.
2. Cooling tower makeup water manifold
3. As indicated on drawings or specifications.

F. Valve Orientation:

1. Where possible, install ball and globe valves that are installed in horizontal piping, with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping, with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:
1. Locate valves for easy access, and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:
1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:
1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt-tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Use same designation at each end for each piece of wire, cable, and tubing for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with valve identification on valve and on face of ceiling directly below valves concealed above ceilings. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.6 ELECTRICAL CONNECTIONS

A. Install electrical power to field-mounted control devices requiring electrical power.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
   2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 CONTROL CONNECTIONS

A.

B. Install control signal wiring to field-mounted control devices.

C. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 STARTUP

A. Control Valve Checkout:
   1. Check installed products before continuity tests, leak tests, and calibration.
   2. Check valves for proper location and accessibility.

3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.
6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications.

C. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular control dampers with airfoil blades.
2. Rectangular control dampers with insulated blades.
3. Electric and electronic control-damper actuators.

B. Related Requirements:

1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

C. Thermal Efficiency Ratio (E): Comparison of a tested damper's thermal performance against a v-groove blade reference damper. A damper with the same thermal efficiency as the reference damper would have an E value of 0 percent, while a damper that is 4 times as efficient would have an E value of 200 percent.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of damper and actuator:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.

4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittals:

1. Schedule and design calculations for control dampers and actuators, including the following:

a. Unique designation for each damper/actuator assembly.
b. Service/application.
c. Damper assembly weight, including actuator(s).
d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
e. Maximum close-off pressure.
f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Damper torque required at worst-case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator fail-safe position on loss of power and loss of signal.
j. Remarks listing special requirements.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are indicated and coordinated with each other, using input from installers of the items involved:

1. Product installation location indicated in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE 62.1 Compliance: Applicable outdoor ventilation requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. Code Compliance: Comply with governing energy code.

E. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.

F. Backup Power Source: Serve control-damper actuators from a backup power source where associated with systems and equipment served by a backup power source.

G. Environmental Conditions: For actuators not available with integral enclosures complying with requirements indicated, house in protective secondary enclosures complying with requirements.

H. Selection Criteria:

1. Multi-Blade Damper Configuration: As follows unless otherwise indicated on Drawings:

   a. Two-Position Control: Parallel.
   b. Equipment Isolation Applications: Parallel.
   c. Face and Bypass Applications: Opposed.
   d. Outdoor/Return Air-Mixing Applications: Opposed.
   e. Modulating Applications: Opposed.

2. Pressure and Temperature: Control dampers suitable for operating conditions encountered by the application:

3. Fail-Safe Positions: As follows unless otherwise indicated on Drawings:

   a. Supply Air: Last position.
   b. Return Air: Last position.
   c. Outdoor Air: Close.
   d. Mixed Air: Open.

e. Exhaust Air: Close.
f. Air Inlet Monitors: Open.
g. Generator Room Exhaust Air: Open.
h. Generator Room Return Air: Open.
i. Boiler Room Emergency Louver: Last Position

4. Select dampers with smooth and stable operation throughout full range of operation over varying pressures and temperatures encountered.
5. Sizing: See Drawings

2.2 RECTANGULAR CONTROL DAMPERS WITH AIRFOIL BLADES

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

   a. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum, galvanized steel, stainless steel) as damper frame.
2. Actuators shall be provided and field installed by temperature controls contractor. Temperature controls contractor shall coordinate with damper manufacturer and mechanical contractor field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements.

B. Rectangular Control Dampers with Aluminum Airfoil Blades and Frames:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Greenheck Fan Corporation.
   b. Johnson Controls, Inc.
   c. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
   d. TAMCO (T. A. Morrison & Co. Inc.).
2. Source Limitations: Obtain rectangular control dampers, with aluminum airfoil blades and frames, from single manufacturer.
3. AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.
4. Performance:

   a. Leakage:

      1) AMCA 511, Class 1A, at 1 in. wg differential static pressure: Leakage not to exceed 3 cfm/sq. ft. against 1 in. wg differential static pressure when tested in accordance with AMCA 500D.

2) AMCA 511, Class 1, at 4 in. wg differential static pressure: Leakage not to exceed 8 cfm/sq. ft. against 4 in. wg differential static pressure when tested in accordance with AMCA 500D.

b. Pressure Drop: 0.05 in. wg at 1500 fpm across a 48-by-48-inch damper when tested in accordance with AMCA 500D, figure 5.3.
c. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure, not less than 6.0 in. wg.
d. Temperature: Minus 40 to plus 250 deg F.
e. Velocity: Up to 6000 fpm.

5. Construction:

a. Frame:

1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum 0.125 inch thick.
2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum 1-1/2 inches for attachment to duct flanges, plenum walls, and equipment.
3) Width: Not less than 5 inches.

b. Blades:

1) Configuration: Parallel or opposed blade configuration as required by application.
2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
3) Shape: Hollow, airfoil.
4) Length: As required by close-off pressure rating, not to exceed 60 inches.
5) Width: Not to exceed 6 inches.

c. Seals:

1) Blades: Replaceable; extruded Santoprene, silicone, or damper manufacturer-offered equivalent, as required by performance requirements. Seals are mechanically attached in extruded blade slots.
2) Jambs: Replaceable; stainless steel, compression type or mechanically attached extruded silicone.

d. Axles:

1) Diameter: Minimum 0.5 inch.
2) Material: Aluminum, or stainless steel.
3) Mechanically attached to blades.

e. Bearings:

1) Material: Molded acetal or stainless-steel sleeve, as required by operating conditions, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Hardware: stainless steel.
2) Material: Aluminum or stainless steel.
3) Mounting: Concealed in frame.

C. Rectangular Control Dampers with Galvanized-Steel Airfoil Blades and Frames:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Greenheck Fan Corporation.
b. Johnson Controls, Inc.
c. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
d. TAMCO (T. A. Morrison & Co. Inc.).

2. Source Limitations: Obtain rectangular control dampers, with galvanized-steel airfoil blades and frames, from single manufacturer.
3. AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance and air leakage.
4. Performance:

a. Leakage:

1) AMCA 511, Class 1A, at 1 in. wg differential static pressure: Leakage not to exceed 3 cfm/sq. ft. against 1 in. wg differential static pressure when tested in accordance with AMCA 500D.
2) AMCA 511, Class 1, at 4 in. wg differential static pressure: Leakage not to exceed 8 cfm/sq. ft. against 4 in. wg differential static pressure when tested in accordance with AMCA 500D.

b. Pressure Drop: 0.06 in. wg at 1500 fpm across a 48-by-48-inch damper when tested in accordance with AMCA 500D, figure 5.3.
c. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure, not less than 6.0 in. wg.
d. Temperature: Minus 40 to plus 250 deg F.
e. Velocity: Up to 6000 fpm.

5. Construction:

a. Frame:

1) Material: ASTM A653/A653M galvanized steel, minimum 0.06 inch thick.
2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum 1-1/2 inches for attachment to duct flanges, plenum walls, and equipment.
3) Width: Not less than 5 inches.

b. Blades:

1) Configuration: Parallel or opposed blade configuration as required by application.
2) Material: ASTM A653/A653M galvanized steel, 0.05 inch thick.
3) Shape: Hollow, airfoil.
4) Length: As required by close-off pressure rating, not to exceed 60 inches.
5) Width: Not to exceed 8 inches.

c. Seals:

1) Blades: Replaceable; extruded silicone, vinyl, or damper manufacturer-offered equivalent, as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
2) Jambs: Stainless steel, compression type.

d. Axles:

1) Diameter: Minimum 0.5 inch.
2) Material: Stainless steel.
3) Mechanically attached to blades.

e. Bearings:

1) Material: Molded acetal or stainless steel sleeve, as required by operating conditions, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Hardware: Stainless steel.
2) Material: Stainless steel.
3) Mounting: Concealed in frame.

2.3 RECTANGULAR CONTROL DAMPERS WITH INSULATED BLADES

A. General Requirements:

1. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
2. Include multisection damper assemblies with intermediate reinforcing where required between individual sections being joined together. Construct reinforcing of same material (aluminum) as damper frame.Actuators shall be provided and field installed by temperature controls contractor. Temperature controls contractor shall coordinate with damper manufacturer and mechanical contractor field requirements for actuators, such as type, fail-safe position, power supply, location, and mounting requirements.

B. Rectangular Control Dampers with Insulated Aluminum Airfoil Blades and Thermal Break Frames:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Greenheck Fan Corporation.
    b. Johnson Controls, Inc.
    c. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
    d. TAMCO (T. A. Morrison & Co. Inc.).

2. Source Limitations: Obtain rectangular control dampers, with insulated aluminum airfoil blades and thermal break, from single manufacturer.
3. AMCA Certification: Test, rate, and seal, in accordance with AMCA 511 for air performance, air leakage, and thermal performance.
4. Performance:

    a. Leakage:

        1) AMCA 511, Class 1A, at 1 in. wg differential static pressure: Leakage not to exceed 3 cfm/sq. ft. against 1 in. wg differential static pressure when tested in accordance with AMCA 500D.
        2) AMCA 511, Class 1, at 4 in. wg differential static pressure: Leakage not to exceed 8 cfm/sq. ft. against 4 in. wg differential static pressure when tested in accordance with AMCA 500D.

    b. Pressure Drop: 0.05 in. wg at 1500 fpm across a 48-by-48-inch damper when tested in accordance with AMCA 500D, figure 5.3.
    c. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure, not less than 8.0 in. wg.
    d. Temperature: Minus 40 to plus 250 deg F.
    e. Thermal Performance:

        1) R-Value: 2.2 or higher.
        2) Thermal Efficiency Ratio (E): 500 or higher when tested in accordance with AMCA 500D.

    f. Velocity: Up to 4000 fpm.

5. Construction:

    a. Frame:

        1) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, minimum 0.125 inch thick.
        2) Arrangement: Hat-shaped channel with integral extended face flange(s) having mating face of minimum 1-1/2 inch for attachment to duct flanges, plenum walls, and equipment.
        3) Thermal Break: Continuous extruded pocket at two locations, one on each side of closed damper blade, with polyurethane resin fill to achieve frame with no through metal.
        4) Width: Not less than 5 inches.

    b. Blades:

        1) Configuration: Parallel or opposed blade configuration as required by application.
        2) Material: ASTM B211/B211M, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
        3) Shape: Airfoil.
        4) Length: As required by close-off pressure rating, not to exceed 60 inches.
        5) Width: Not to exceed 6 inches.
        6) Insulation: Hollow airfoil blade internally insulated with expanded polyurethane foam for thermal performance indicated.
        7) Thermal Break: Complete thermal break with blades in full closed position.

    c. Seals:

        1) Blades: Replaceable; extruded EPDM, Santoprene or silicone, as required by performance requirements. Seals are to be mechanically attached in extruded blade slots.
        2) Jambs: Replaceable; polycarbonate, compression type or mechanically attached extruded silicone.

    d. Axles:

        1) Diameter: Minimum 0.5 inch.
        2) Material: Stainless steel.
        3) Mechanically attached to blades.

    e. Bearings:

        1) Material: Molded inner and outer bearings of acetal or polycarbonate, as required by operating conditions.

2) Mounting: Inner bearing fixed to axle, rotating within an outer bearing inserted in the frame, resulting in no metal-to-metal contact.
3) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Hardware: Stainless steel.
2) Material: Stainless steel.
3) Mounting: Concealed in frame.

g. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish, minimum of 0.0007 inch thick, for aluminum surfaces in contact with airstream.

2.4 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Select actuators to operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Select actuators with sufficient power and torque to close off against the maximum system pressures encountered. Actuators are to be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator is not to exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Operate multiple actuators required to drive a single damper assembly in unison.

E. Avoid the use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail-safe in desired position in the event of a power and signal failure.

I. Actuator Fail-Safe Positions: See Drawings.

2.5 ELECTRIC AND ELECTRONIC CONTROL-DAMPER ACTUATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belimo Aircontrols (USA), Inc.
2. Honeywell Building Solutions; Honeywell International, Inc.
3. Johnson Controls, Inc.
4. Siemens Industry, Inc., Building Technologies Division.

B. Source Limitations: Obtain electric and electronic control-damper actuators from single manufacturer.

C. Type: Motor operated, with or without gears, electric and electronic.

D. Voltage:
1. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
2. Actuator to function properly within a range of 85 to 120 percent of nameplate voltage.

E. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed-steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains are to be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

F. Local Field Adjustment: Make spring-return actuators easily switchable from fail-safe open to fail-safe closed in the field without replacement.

G. Local Manual Override: Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

H. Two-Position Actuators: Single direction, spring return or reversing type.

I. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 0 to 10 V dc and 4 to 20 mA signals.
c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
d. Programmable Multifunction:

1) Control input, position feedback, and running time are to be factory or field programmable.
2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service data, including at a minimum, number of hours powered and number of hours in motion.

J. Position Feedback:

1. Where indicated, equip two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

K. Fail-Safe:

1. Where indicated, provide actuator to fail-safe to an end position.
2. Internal spring-return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other nonmechanical forms of fail-safe operation are acceptable only where uniquely indicated.

L. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

M. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.

3. Bolt and setscrew method of attachment is acceptable only if provided with at least two points of attachment.

N. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range is to be from 5 to 95 percent relative humidity, noncondensing.

O. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 4 for indoor and protected applications.
3. NEMA 250, Type 4X for outdoor and unprotected applications.
4. NEMA 250, Type 9 for hazardous applications requiring explosion-proof construction.
5. Provide actuator enclosure with a heater and controller where required by application.

P. Stroke Time:

1. Select operating stroke time to be compatible with equipment and system operation, and as follows.

    a. Operate damper from fully closed to fully open position within 90 seconds.
    b. Operate damper from fully open to fully closed position within 90 seconds.
    c. Move damper to fail-safe position within 15 seconds.

2. For actuators operating in generator room and other life-safety systems, comply with governing code and NFPA requirements.

    a. Operate damper from fully closed to fully open position within 5 seconds.
    b. Operate damper from fully open to fully closed position within 10 seconds.
    c. Move damper to fail-safe position within 5 seconds.

Q. Sound: Where actuators are located in tenant-occupied rooms with a room sound-level criteria of NC-35 or lower, comply with the following sound levels:

1. Spring Return: 45 dBA.
2. Nonspring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL-DAMPER APPLICATIONS

A. Select from damper types indicated to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Rectangular Control-Damper Applications:
1. Return Air: Rectangular dampers with aluminum airfoil blades.
2. Supply Air: Rectangular dampers with aluminum airfoil blades.

C. Rectangular Control Dampers with Insulated Blade Applications:

1. Exhaust Air: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames.
2. Outdoor Air: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames.

3. Air Monitor Inlet: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames.

4. Generator Room Exhaust Air: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames.

5. Generator Room Return Air: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames.

6. Boiler Room Emergency Air: Rectangular dampers with insulated aluminum airfoil blades and thermal break frames.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic, wind, or others forces common to the application.

C. Provide ceiling, floor, roof,wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 30 degrees, to dampers larger or smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access unless more space is recommended by manufacturer. Provide code required clearances as applicable.

C. Service Access:

1. Install dampers and actuators to be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions.

E. Install supplementary structural reinforcement for large multiple-section dampers if factory-furnished support alone cannot handle loading.

F. Attach field-installed actuator(s) to damper drive shaft.

G. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire and cable is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with damper identification on damper and on face of ceiling where damper is concealed above ceiling.

3.6 ELECTRICAL CONNECTIONS

A. Install electrical power to field-mounted control devices requiring electrical power.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.7 CONTROL CONNECTIONS

A. Install control signal wiring to field-mounted control devices.

B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Furnish and install raceways. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems."

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 STARTUP

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and damper linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is smooth and unobstructed throughout operating range.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

SECTION 230923.13 - ENERGY METERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermal energy meters.
2. Electric power meters. (See division 26 electrical specifications)

B. Related Requirements:

1. Section 230923 "Direct-Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.
3. Section 260913 "Electrical Power Monitoring" for electrical power meters not included in this Section.

1.2 DEFINITIONS

A. DDC: Direct-digital control.

B. DIN: Deutsche Institut fur Normung (German Institute for Standards).

C. DZR: Dezincification resistant.

D. Ethernet: Local area network based on IEEE 802.3.1.

E. EEPROM: Electrically erasable programmable read-only memory.

F. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

G. I/O: Input/output.

H. IP: Ingress protection ratings.

I. PEEK: Polyetheretherketone.

J. PLC: Programmable logic controller.

K. PPS: Polyphenylene sulfide.

L. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

M. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

N. RS-485: A TIA standard for multipoint communications using two twisted pairs.

O. RTD: Resistance temperature detector.

1.3 ACTION SUBMITTALS

A. Product Data: For thermal energy meters and electric power meters, include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating electrical power requirements.
3. Product description with complete technical data, performance curves, and product specification sheets.

B. Sustainable Design Submittals:

1. Product Data for EA Credit "Advanced Energy Metering": For continuous metering equipment.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product and component requiring a certificate.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For energy meters to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 THERMAL ENERGY METERS

A. Performance Requirements: Manufacturer is to certify that each energy meter complies with specified performance requirements and characteristics.

1. Product certificates are required.
   a.

B. Thermal Energy Meter with Insertion Electromagnetic Flow Sensor:

1. Manufacturers: Subject to compliance with requirements, a**vailable manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**:

   a. Dwyer Instruments, Inc.
   b. ONICON Incorporated.
   c. <**Insert manufacturer's name**>.

2. Description:

   a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
   b. Factory calibrate each thermal energy meter and provide with calibration certification traceable to NIST.

3. Performance:

   a. Ambient Operating Temperature: Minus 20 to plus 140 deg F.
   b. Energy Calculation Nonlinearity: Within 0.05 percent.
   c. Fluid Electrical Conductivity: Suitable for fluids with electrical conductivity between 20 to 60000 microseimens per centimeter.
   d. Flow Sensor Accuracy:

      1) Accuracy for velocities between 2 and 20 fps to be within 1 percent of reading.
      2) Accuracy for velocities less than 2 fps to be within 0.02 fps.

   e. Flow Sensor Pressure Drop: Not to exceed 0.1 psig at 12 fps flow velocity in NPS 3 pipe and decreasing in larger pipe with lower velocity.

f. Flow Sensor Velocity Range: 0.25 to 20 fps.
g. Process Pipe Sizes: NPS 1-1/4 through NPS 48.
h. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.

1) Pressure: Up to 400 psig.
2) Temperature: Within 25 to 250 deg F.

i. Process Temperature Accuracy: Differential temperature accuracy within 0.15 deg F over the calibrated range.

4. Meter Display: Backlit, LCD alphanumeric display of the following on face of meter enclosure:

a. Total energy consumption.
b. Energy rate.
c. Flow rate.
d. Supply temperature.
e. Return temperature.
f. Visual indication of power status (on/off) on face of enclosure.

5. Meter Electronics Enclosure:

a. Remote mounted from temperature and flow sensors.
b. Indoor Applications: NEMA 250, Type 4 or 13.
c. Outdoor Applications: NEMA 250, Type 4.
d. Labeled terminal strip for field wiring connections.
e. Connections: Suitable for mating to field-installed conduit.

6. Power Supply:

a. Field Power: 24, 120, 240 V ac, 50 or 60 Hz as required by the application.
b. Internal Power: As required by flow meter.

7. Programming:

a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
b. Programmed parameters and total energy consumption stored in non-volatile EEPROM memory.

8. Output Signals:

a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating and contact duration of 0.5, 1, 2, or 6 seconds.
b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
c. Option to use serial communication interface in lieu of hardwired signals

9. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
10. Flow Sensor:

    a. Factory Calibration: Wet calibrate and tag each sensor to standards traceable to NIST, and provide each sensor with a certificate of calibration.
    b. Sensor Head: Polysulfone.
    c. Construction: Wetted metal components of Type 316 stainless steel, including the installation hardware.
    d. Enclosure: House electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover and conduit connections.
    e. Installation Hardware: Provide installation hardware necessary to enable insertion and removal from the pipe without system shutdown.
    f. Isolation Valve: Provide sensor with full-port Type 316 stainless steel ball valve for system isolation.
    g. Sensor Cable: As required by manufacturer for application.

11. Temperature Sensors:

    a. Enclosure: NEMA 250, Type 4 with conduit connections.
    b. Sensor Cable: As required by manufacturer for application.
    c. Temperature Range: Matched pair; suitable for application.
    d. Thermowells: Stainless steel; with NPT connections.

C. Thermal Energy Meter with In-Line Electromagnetic Flow Sensor:

1. Manufacturers: Subject to compliance with requirements, **available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**:

    a. Armstrong International, Inc.
    b. ONICON Incorporated.
    c. <**Insert manufacturer's name**>.

2. Description:

    a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
    b. Factory calibrate each thermal energy meter and provide with calibration certification traceable to NIST.

3. Performance:

    a. Ambient Operating Temperature: Minus 20 to plus 140 deg F.
    b. Energy Calculation Nonlinearity: Within 0.05 percent.
    c. Fluid Electrical Conductivity: Suitable for fluids with electrical conductivity greater than 5 microseimens per centimeter.
    d. Flow Sensor Accuracy:

1) Accuracy for velocities between 2 and 20 fps to be within 0.2 percent of reading.
2) Accuracy for velocities less than 2 fps to be within 0.0004 fps.

e. Flow Sensor Pressure Drop: No permanent pressure drop.
f. Flow Sensor Velocity: 0.1 to 20 fps.
g. Process Pipe Sizes: NPS 1 through NPS 48.
h. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.

1) Pressure: Up to 225 psig.
2) Temperature: Within 25 to 250 deg F.

i. Process Temperature Accuracy: Differential temperature accuracy within 0.15 deg F over the calibrated range.

4. Meter Display: Backlit, LCD alphanumeric display of the following on face of meter enclosure:

a. Total energy consumption.
b. Energy rate.
c. Flow rate.
d. Supply temperature.
e. Return temperature.
f. Visual indication of power status (on/off) on face of enclosure.

5. Meter Electronics Enclosure:

a. Remote mounted from temperature and flow sensors.
b. Indoor Applications: NEMA 250, Type 4 or 13.
c. Outdoor Applications: NEMA 250, Type 4.
d. Labeled terminal strip for field wiring connections.
e. Connections: Suitable for mating to field-installed conduit.

6. Power Supply:

a. Field Power: 24, 120, 240 V ac, 50 or 60 Hz as required by the application.
b. Internal Power: As required by flow meter.

7. Programming:

a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
b. Programmed parameters and total energy consumption stored in non-volatile EEPROM memory.

8. Output Signals:

a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating and contact duration of 0.5, 1, 2, or 6 seconds.
b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
c. Option to use serial communication interface in lieu of hardwired signals.

9. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
10. Flow Sensor:

a. Factory Calibration: Wet calibrate and tag each sensor to standards traceable to NIST, and provide each sensor with a certificate of calibration.
b. Body Connection: Flange, suitable for mating to adjacent pipe flange.
c. Body Material: Epoxy-coated carbon steel.
d. Body Liner Material: PTFE.
e. Flow Tube: Type 304 or 316 stainless steel.
f. Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.
g. Enclosure: House electronics in a NEMA 250, Type 4 enclosure with conduit connections.
h. Sensor Cable: As required by manufacturer for application.

11. Temperature Sensors:

a. Enclosure: NEMA 250, Type 4 with conduit connections.
b. Sensor Cable: As required by manufacturer for application.
c. Temperature Range: Matched pair; suitable for application.
d. Thermowells: Stainless steel; with NPT connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 THERMAL ENERGY METER APPLICATIONS

A.

B. Thermal Energy Meters with Insertion Electromagnetic Flow Sensor: CHW, CTW, HHW NPS 8” and above..

C. Thermal Energy Meters with In-Line Electromagnetic Flow Sensor: CHW, CTW, HHW NPS 6” and below.

D.

E.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic forces.

C. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

D. Mount meters located in mechanical and electrical rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches, but preferably at 60 inches above the adjacent floor, grade, or service catwalk or platform.

3.4 INSTALLATION OF THERMAL METERS

A. Install meters not integral to flow sensors in vicinity of flow sensor. Where multiple meters are serving same system and located in same room, co-locate them by system to provide service personnel a single and convenient location for inspection and service.

B. Install meter flow sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream.

C. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.

D. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on performance.

E. Install in-line meters with flanges or unions to provide drop-in and -out installation.

F. Insertion Meters:

1. Install system process connections full size of meter connection, but not less than NPS 1-1/2. Provide stainless steel bushing if required to mate to system connection.
2. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

G.

3.5 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Furnish and install raceways. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems."

E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control signal wiring to field-mounted control devices.

B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Furnish and install raceways. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire and cable is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 CHECKOUT PROCEDURES

A. Checkout Requirements:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that sensors are installed correctly with respect to flow direction.
5. Verify that sensor attachment is properly secured and sealed.
6. Inspect meter tags against approved submittal.
7. Verify that recommended upstream and downstream distances have been maintained.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. Equipment and procedures used for calibration are to meet instrument manufacturer's written instructions.
4. Provide diagnostic and test equipment for calibration and adjustment.
5. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
6. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
7. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11 in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

3.11 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, verify that maintenance service includes 12 months' full maintenance by skilled employees of systems and equipment Installer. Include semiannual preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 230923.13

SECTION 230923.14 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Airflow measurement stations and sensors.
2. Liquid flow meters.
3. Liquid flow sensors (primary elements).
4. Liquid flow switches.
5. Liquid flow transmitters.

B. Related Requirements:

1. Section 230923 "Direct Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993.11 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. FEP: Fluorinated ethylene propylene.

C. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

D. PEEK: Polyetheretherketone.

E. PTFE: Polytetrafluoroethylene.

F. PPS: Polyphenylene sulfide.

G. RS-485: A TIA standard for multipoint communications using two twisted pairs.

H. RTD: Resistance temperature detector.

I. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Airflow measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Liquid flow sensors (primary elements).
6. Liquid flow switches.
7. Liquid flow transmitters.

B. Product Data Submittals: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.
5. Product certificates.

C. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

D. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

E. Delegated Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.

a. Flow at Project design and minimum flow conditions.

b. Pressure drop at Project design and minimum flow conditions.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

B. Product Test Reports: Tests performed by a qualified testing agency.

1. Airflow measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Liquid flow sensors (primary elements).
6. Liquid flow switches.
7. Liquid flow transmitters.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during one-year period following warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters are to have an extended range of 20 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Liquid and steam sensors, meters, and transmitters are to have an extended range of 20 percent above Project design flow and 10 percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

C. Source Limitations: For flow instruments, obtain products from single source from single manufacturer.

2.3 AIRFLOW MEASUREMENT STATIONS AND SENSORS

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions.
3. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

B. Thermal Airflow Measurement Stations:

1. Common Performance Requirements:

    a. Provide stations that are adjustable for changes in system operational parameters.
    b. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
    c. Thermal airflow stations with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.
    d. Sensor Nodes: One self-heated and one zero-power bead-in-glass thermistor, using the principle of thermal dispersion.
    e. Airflow Rate and Temperature of Each Sensor: Equally weighted and averaged by the transmitter prior to output.
    f. Sensor-Node and Probe Assemblies:

        1) Sensor-Node Construction: Two bead-in-glass, hermetically sealed thermistors potted in a marine-grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Construct with only the thermistor located within the sensing node and all other electronic components outside the airstream. Epoxy- or glass-encapsulated chip thermistors or devices with exposed leads are not allowed. Devices that use epoxy- or glass-encapsulated chip thermistors, or electronics in the airstream, are unacceptable. Devices with exposed leads are un acceptable.
        2) Store sensor-node airflow and temperature calibration data in a serial memory chip, in the cable connecting plug. Stored data does not require matching or adjustments to the transmitter in the field.

3) Sensing-Node Temperature Accuracy: Within 0.15 deg F over an operating range of minus 20 to plus 160 deg F and humidity range of 0 to 100 percent RH.
4) Sensor-Probe Mounting Bracket Construction: Type 304 stainless steel.
5) Internal Probe Wiring: Kynar-coated copper between the connecting cable and sensor nodes. PVC-jacketed wiring is unacceptable.
6) Internal Probe Wiring Connections: Solder joints and spot welds, sealed and protected from the elements, so that direct exposure to water will not affect instrument operation. Connectors within the probe, of any type, are unacceptable. Printed circuit boards within the probe are unacceptable.
7) Sensor-Probe Jacket: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F, and for continuous and direct UV exposure. Plenum-rated PVC jacket cables are unacceptable.
8) Sensor-Probe Cable Connector Plug: Gold-plated pins for connection to the transmitter.

g. Transmitter Features and Functions:

1) High and/or low airflow alarm with user-defined set point and percent of set-point tolerance.
2) Manual or automatic alarm reset, and low-limit cutoff value may be selected to disable the alarm.
3) Alarm delay function, field defined.
4) Sensor-node malfunction via the system status alarm and ignore the sensor node that is in a fault condition.
5) Field configuration, diagnostics, and field output adjustment wizard that allow for a one- or two-point field adjustment to factory calibration for installations that require adjustment.
6) Automatic reset after power disruption, transients, and brown-outs through a watchdog timer circuit.
7) Operating temperature range of minus 20 to plus 120 deg F and humidity range of 5 to 95 percent RH.
8) Electrical Power Requirement: 24 V ac (between 22.8 and 26.4 V ac under load) at 20 VA maximum, using a switching power supply that is overcurrent and overvoltage protected.
9) Printed Circuit Board Interconnects: Gold-plated edge fingers, receptacle plug pins, and printed circuit board test points.
10) Printed Circuit Boards: Electroless nickel immersion gold (ENIG) plated.
11) Integrated Circuitry: Temperature-rated, industrial-grade. Commercial-grade integrated circuitry is not acceptable.
12) Integration Buffers: Separate integration buffers for display of airflow output, airflow signal output (analog and network), and individual sensor output (IR-interface).

2. For Air-Ducted/Plenum:

a. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1) EBTRON
b. Airflow Station Performance:

   1) Independent processing of up to 16 separately wired sensor-node assemblies.
   2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

c. Sensor-Node and Probe Assemblies:

   1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory results.
   2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

      a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm.
      b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

   3) Provide the number of independent sensor nodes as follows:

      a) For Duct/Plenum Area up to 0.5 sq. ft. (0.046 sq. m): One.
      b) For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft. (0.046 through 0.092 sq. m): Two.
      c) For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft. (0.186 through 0.372 sq. m): Six.
      d) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Eight.
      e) For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): 12.
      f) For Duct/Plenum Area Greater Than 12.0 through 14.0 sq. ft. (1.11 through 1.30 sq. m): 14.
      g) For Duct/Plenum Area Greater Than 14.0 sq. ft. (1.30 sq. m): 16.

   4) For an aspect ratio of 1.5 or less, and an area of 25 sq. ft. or greater, four probes are required.

5) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube or Type 316 stainless steel tube, with each sensor probe containing one or more independently wired sensing nodes.

d. Transmitter:

1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

a) Model GTC116 Transmitter: Two field-selectable 0-to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter is to be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software is to allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
b) Model GTM116 Transmitter: Two field-selectable 0- to 10-V dc, or4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter is to be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software is to allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

3. For Supply or Return Fan Array:
   a. Manufacturers: Subject to compliance with requirements, provide products by the following:
      1) EBTRON
   b. Airflow Station Performance:

      1) Independent processing of up to eight separately wired sensor-node assemblies.
      2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

   c. Sensor-Node and Probe Assemblies:

      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm.
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

      3) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.
      4) Number of Independent Sensor Nodes, Fan Arrays (One to Eight Fans): One probe with one sensor node per probe in each fan inlet.

   d. Transmitter:

      1) Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
      2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

         a) Model GTC108 Transmitter: Two field-selectable 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for

temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter is to be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software is to allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

b) Model GTM108 Transmitter: Two field-selectable 0- to 10-V dc, or4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter is to be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software is to allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

2.4 LIQUID FLOW METERS

A. General Requirements for Liquid Flow Meters:

1. Adjustable for changes in system operational parameters.
2. Liquid and Steam Sensors, Meters, and Transmitters: Extended range of 20 percent above Project design flow and 10 percent below Project minimum flow to signal abnormal flow conditions.
3. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
4. Product certificates are required.

B. Insertion Electromagnetic Flow Meter:
1. Available manufactures include, but are not limited to the following:

a. Onicon
b. Endress + Hauser
c. Approved Equal

2. Description:

a. No moving parts.
b. Suitable for flow measurement of fluids with electrical conductivity between 20 to 60000 micro-Seimens per centimeter.
c. Suitable for pipe sizes NPS 3 through NPS 72.
d. Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
e. Continuous auto-zero function.
f. Transmitter integral to meter.

3. Performance:

a. Flow Range: 0.25 to 20 fps.
b. Accuracy for Velocities between 2 and 20 fps: Within ±1 percent of reading.
c. Accuracy for Velocities Less than 2 fps : Within ±0.02 fps.
d. Ambient Temperature: Minus 5 to 150 deg F.
e. Process Temperature: 15 to 250 deg F.
f. Pressure: 400 psig.

4. Output Signals:

a. Field-selectable analog signals.

1) Current Signal (Isolated): 4 to 20 mA.
2) Voltage Signal (Isolated): Zero- to 10-V dc.

b. Digital Signal: Dry-contact closure signaling fault condition.
c. Frequency Signal: Zero- to 15-V peak pulse, zero to 500 Hz.
d. Scalable Pulse Output:

1) Isolated solid-state dry contact.
2) Contact Rating: 100 mA at 50-V dc.
3) Pulse Duration: 0.5, 1, 2, or 6 seconds.

5. Construction:

a. Wetted Metal Parts: Type 316 stainless steel.
b. Sensor Head: Polysulfone.
c. Process Connection: 1 inch.
d. Instrument Isolation Valve: Full port Type 316 stainless steel ball valve for system isolation.
e. Electrodes: Type 316 stainless steel.
f. Electronics Enclosure:

1) Painted aluminum.

2) Removable cover.
3) NEMA 250, Type 4.
4) Electrical Connection: PVC-jacketed cable, 10 feet long.
5) Conduit Connection: 1/2-inch trade size.

6. Display Module:

a. Remote from meter.
b. House in a NEMA 250, Type 4X enclosure.
c. Label terminal strip for all wiring connections.
d. 120-V ac power supply with 24-V dc output to power the flow sensor.
e. Input Signal from Meter: Zero- to 15-V pulse output.
f. Output Signals: Additional output signals furnished with flow meter connected to display module terminal strip.
g. Auxiliary Output Signals:

1) Analog current output (isolated) is to be 4 to 20 mA.

h. Digital Display:

1) Flow rate.
2) Totalized flow.
3) At least six display digits for flow rate and eight display digits for totalization.
4) Bi-directional units with separate digital display for flow and totalization in each direction.

i. Local reset of flow totalization.
j. Program and data are to be stored in nonvolatile memory in the event of power loss.
k. For bi-directional units, provide LED display of flow direction (contacts open or closed).
l.

C. Vortex Shedding Flow Meter with Integral Pressure and Temperature Measurement:
1. Available manufactures include, but are not limited to the following:
a. Onicon
b. Endress + Hauser
c. McCometer
d. Approved Equal

2. Description:

a. Mass flow measurement corrected for density using vortex shedder body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.
b. Meter NPS 1/2 through NPS 12.
c. Each meter is to be factory calibrated at five points from zero to 250 fps and tagged accordingly against the manufacturer's flow standards. The manufacturer is to provide a certificate of calibration for meter.
d. Each meter is to be programmed using project-specific application data.

e. Meter is to include integral diagnostics to verify installation conditions and proper operation.

3. Performance:

a. Volumetric Flow Accuracy for Liquid: Within 0.75 percent of reading for Reynolds numbers 20000 and larger.
b. Volumetric Flow Accuracy for Steam and Gas: Within 1 percent of reading for Reynolds numbers 20000 and larger.
c. Mass Flow Accuracy for Steam and Gas: Within 1.5 percent of reading for Reynolds numbers 20000 and larger.
d. Repeatability: Within 0.1 percent.
e. Long-Term Stability: Within 0.1 percent per year.
f. Ambient Temperature: Minus 40 to plus 185 deg F.
g. Process Temperature: Minus 40 to plus 464 deg F.
h. Pressure: Equal to flange rating.

4. Output Signals:

a. Analog Current Signal of Flow Rate:

1) Two-wire, 4- to 20-mA dc current source.
2) Signal capable of operating into 1000-ohm load.

b. Analog Current Signals for Pressure and Temperature: Separate 4- to 20-mA signals for gage pressure and temperature.
c. Digital Signal:

1) Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30-V dc.
2) HART, FSK protocol.

5. Operator Interface:

a. Keypad.
b. Digital Display: Two-line digital display of alphanumerical characters. The meter is to display flow rate, flow totalization, pressure, temperature, and support field programming of all parameters.

6. Construction:

a. Material: Type 316L stainless steel.
b. Connection: Class 150 flange.
c. Enclosure:

1) Epoxy-painted cast aluminum.
2) Removable screw-on cover.
3) NEMA 250, Type 6.
4) Electrical Connection: Screw terminals.
5) Conduit Connection: Two, 1/2-inch trade size.

7. Upstream Flow Straightener:

    a. Meter manufacturer is to provide flow straightener where required by installation to comply with manufacturer's installation recommendations.
    b. Straightener is to be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.
    c. Straightener size is to match meter size.

2.5 LIQUID FLOW SENSORS (PRIMARY ELEMENTS)

A. Venturis:
1. Available manufactures include, but are not limited to the following:
    a. Griswold
    b. Prerso
    c. Xylem
    d. Approved Equal

2. Requirements in remaining subparagraphs below are based on Preso Meters' "Model VB, CV and SSM Series."
3. On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.
4. Standard: ASME MFC-3M.
5. Performance:

    a. Accuracy within 0.5 percent of measured flow throughout flow range from design to 10 percent of design flow.
    b. Accuracy with five pipe diameters of straight pipe upstream and two pipe diameters downstream.
    c. Size and beta ratio are to be matched with transmitter to provide accuracy of entire assembly within 1 percent of design flow rate, when the flow rate is allowed to vary between 10 to 100 percent of the design.

6. Construction:

    a. One-piece bronze or brass construction with threaded connections for pipe sizes NPS 1/2 through NPS 2.
    b. One-piece plated cast steel with flanged connections for pipe sizes NPS 2-1/2 through NPS 8, and fabricated steel with flanged connections for larger sizes.
    c. Sensing Taps: Two, accurately located built-in sensing taps, nipples, shut-off valves, and quick connect coupling.
    d. Identification Tag: Attached to each venturi with a chain and label indicating pipe size, venturi series, station identification, and meter reading at flow rate and pressure differential.
    e. Use venturi with pressure differential transmitter.

B. Portable Meter Package for Liquid Flow Sensors:

1. Metal-reinforced-plastic carrying case.

2. Waterproof meter with nominal 6-inch round dial face.
3. Meter with dual rupture-proof liquid-filled bellows having integral temperature compensation.
4. Meter with external range and zero adjustment.
5. Multiple meters in package, if required to accommodate venturis with a wide range of pressure signals.
6. Two connecting hoses, 10 feet long, with quick connect couplings compatible with venturi couplings.
7. Two brass blowdown valves with Buna-N seals and blowdown hoses.
8. Instruction book with flow versus differential curves.
9. Suitable for working pressure of 200 psig at 200 deg F.
10. Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide isolation valves at connections.
11. Turn over to Owner at Project completion.

2.6 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Magnetic Type):

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. W.E. Anderson; a division of Dwyer Instruments, Inc.
   b. Approved equal

2. Description:

   a. Field-adjustable five-vane combinations.
   b. Suitable for pipe sizes NPS 1-1/2 through NPS 48.
   c. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.

3. Performance:

   a. Flow Rate Actuation and De-actuation: Varies with vane combination.
   b. Pressure Limit: 1000 psig for brass body, 2000 psig for Type 316 stainless steel body.
   c. Temperature Range: Minus 4 to plus 275 deg F.
   d. Electrical Rating: 10 A at 125/250-V ac.
   e. Switch Type: SPDT or DPDT snap switch as needed for application.

4. Wetted Parts Construction:

   a. Vanes: Type 316 stainless steel.
   b. Body: Brass Type 316 stainless steel.

c. Magnetic Keeper: Type 430 stainless steel or Type 316 stainless steel.
d. Process Connection: NPS 1-1/2.

5. Enclosure:

a. Die-cast aluminum alloy.
b. Threaded cover.
c. NEMA 250, Type 4.
d. Electrical Connection: Terminal block.
e. Conduit Connection: 3/4-inch trade size.

2.7 LIQUID FLOW TRANSMITTERS

A. Pressure Differential Transmitter with 0.07 Percent Accuracy for Flow Measurement: For use in hazardous environment.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. FM Approved for hazardous environments.

a. Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, Groups A through H.
b. Explosion-Proof for Class I, Division 1, Groups B, C, and D.
c. Dust-Ignition-Proof for Class II, Division 1, Groups E, F, and G.
d. Dust-Ignition-Proof for Class III, Division 1.

3. Performance:

a. Range: Minus 250- to 250-inch wg.
b. Span: Field adjustable.
c. Minimum Span: 2.5-inch wg.
d. Accuracy: Within 0.07 percent of span or better.
e. Stability: Within 0.125 percent of upper range limit for 5 years.
f. Overpressure Limits: 3626 psig.
g. Process Temperature Limits: Minus 40 to plus 250 deg F.
h. Ambient Temperature Limits: Minus 40 to plus 185 deg F.
i. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
j. Shock and vibration are not to harm the transmitter.

4. Analog Output Current Signal:

a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into 1000-ohm load.
c. Digital signal based on HART protocol carried with current signal.
d. Dampening: Field selectable zero to 30 seconds.

5. Operator Interface: Zero and span adjustments located behind cover.

6. Display: Five-digit, two-line digital display with 0.4-inch-high alphanumeric characters.
7. Construction:

    a. Nonwetted parts of transmitter constructed of aluminum or stainless steel.
    b. Enclosure with removable cover on each side.
    c. Wetted parts of transmitter constructed of Type 316 stainless steel.
    d. NPS 1/2 process connections on bottom of instrument.
    e. Drain/vent valve on low- and high-pressure connections.
    f. Two 1/2-inch trade size conduit connection on side of instrument enclosure.
    g. Screw terminal block for wire connections.
    h. NEMA 250, Type 4X.
    i. Mounting bracket suitable for installation.

8. Five-Valve Manifold:

    a. Each transmitter is to have integrally mounted manifold.
    b. Construct manifold body of Type 316 stainless steel.
    c. Manifold is to have NPS 1/2 process connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Thermal Airflow Measurement Stations:

1. For Air-Ducted/Plenum:

   a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

2. For Supply or Return Fan Array:

   a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

C. Duct-Mounted Airflow Sensors:

1. Measured Velocities 500 fpm (2.5 m/s) and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm (2.5 m/s): Thermal airflow station.

D. Liquid Flow Sensors (Primary Elements):

1. Chilled Water Condenser Water and Heating Hot water System ,Component flow rate: Venturis.

E. Liquid Flow Meters:

1. Chilled Water, Condenser Water, Steam Condensate, and Heating Hot Water Systems, Pipe Main and branch main flow: Turbine flow meter or Electromagnetic flow meter.

2. Steam Mains, Pipe Main and branch main flow: Vortex meters with temperature and pressure compensation.

F. Liquid Flow Switches:

1. Chilled Water, Condenser Water, Steam Condensate, and Heating Hot Water Systems System: Magnetic type.

G. Liquid Flow Transmitters:

1. Chilled water, condenser water, heating hot water, steam and condensate Systems, Pipe mains: Pressure differential transmitter with 0.07 percent accuracy for flow measurement or Liquid pressure differential transmitter.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 20kN force.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.5 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height is to comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.6 INSTALLATION OF FLOW INSTRUMENTS

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors are to be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Liquid and Steam Sensors:

1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.
4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.

C. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Insertion Meters:

    a. Install system process connections full size of meter connection, but not less than NPS 1. Provide stainless steel bushing if required to mate to system connection.
    b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
    c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

D. Liquid Switches:

1. Install system process connection full size of switch connection, but not less than NPS 1. Install stainless steel bushing if required to mate switch to system connection.
2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:
1. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing are to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration are to meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments are to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.11 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service is to include 12 months full maintenance by skilled employees of systems and equipment Installer. Include semiannual preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies are to be manufacturer's authorized replacement parts and supplies.

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner is to have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.14

SECTION 230923.16 - GAS INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes the Following Gas Instruments:
   1. Refrigerant Monitoring system.

B. Related Requirements:

   1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

   1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   2. Installation instructions, including factor affecting performance.
   3. Product description with complete technical data, performance curves, product specification sheets.

B. Shop Drawings:

   1. Include plans, elevations, sections, and mounting details.
   2. Include diagrams for power, signal, and control wiring.
   3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.

B. Product Test Reports: For each product, for tests performed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 REGRIGERANT MONITORING SYSTEM

A. MANUFACTURERS

B. Subject to compliance with requirements, provide products by the following:

1. Refrigerant Monitoring Equipment: Bacharach HGM-MZ.

C. FUNCTIONAL DESCRIPTION OF REFRIGERANT MONITORING SYSTEM

D. Each refrigerant monitor shall be capable of detecting and transmitting the following information. Transmission of information shall be to the BAS via contacts and hard wiring (TO I/O cards) or through RS485

1. No leak detected – monitor functioning normally
2. Monitor functioning abnormally or no signal available (fault)
3. Leak detected of 0-100 ppm concentration.
4. Leak detected of 101-1000 ppm concentration.
5. Leak detected – concentration off scale.

E. REFRIGERANT MONITOR CENTRIFUGAL CHILLERS
1. Description: Non-dispersive infrared sensor shall continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and shutting down equipment, and automatically activating ventilation system.
2. Performance Requirements:
   a. Refrigerant to Be Monitored: R-1233zd(E), 6 sampling zones minimum.

b. Refrigerant Concentration: 0 to 1000 ppm.
c. Accuracy: ±1 PPM ±10% of reading from 0-1,000 PPM.
d. Linearity: 100 to 1000 ppm; plus or minus 2 percent of full scale.
e. Sensitivity: 1 ppm.
f. Resolution: 1 ppm.
g. Operating Temperature: 41 to 104 deg F
h. Response Time: 90 percent of a step change in 4 minutes.
i. Relatively Humidity: 20 to 95 percent, non-condensing over the operating temperature range.

3. Operating Requirements:
a. Maximum Power Input: 120-V ac; 60 Hz, 30 W.
b. Alarm Relays: 4 relays at 2 Amp resistive load.
c. Alarm Set Points: Displayed on front of meter.
d. Fault Relay: 1 relay at 5- to 8-A resistive load.
e. Zone Area: 4- to 20-mA signal.
f. BACnet interface converter kit supplied with refrigerant monitor to communicate with BAS.
g. Audible/Visual Output: Provide three (3) combination horn/flashing red strobes as part of the monitoring system. Horn/Strobes to be field mounted by others.

4. Detector type: Infrared non-dispersive.
5. Display: Alphanumeric.
6. Enclosure: NEMA 250 or type as required for ambient condition.
7. Alarm Output: Contact closure.
8. Calibration: Factory calibrated.

F. REFRIGERANT MONITOR HEAT RECOVERY CHILLERS
1. Description: Non-dispersive infrared sensor shall continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and shutting down equipment, and automatically activating ventilation system.
2. Performance Requirements:
a. Refrigerant to Be Monitored: R-513A, 8 sampling zones minimum.
b. Refrigerant Concentration: 0 to 1000 ppm.
c. Accuracy: ±1 PPM ±10% of reading from 0-1,000 PPM.
d. Linearity: 100 to 1000 ppm; plus or minus 2 percent of full scale.
e. Sensitivity: 1 ppm.
f. Resolution: 1 ppm.
g. Operating Temperature: 41 to 104 deg F
h. Response Time: 90 percent of a step change in 4 minutes.
i. Relatively Humidity: 20 to 95 percent, non-condensing over the operating temperature range.

3. Operating Requirements:
a. Maximum Power Input: 120-V ac; 60 Hz, 30 W.
b. Alarm Relays: 4 relays at 2 Amp resistive load.
c. Alarm Set Points: Displayed on front of meter.
d. Fault Relay: 1 relay at 5- to 8-A resistive load.
e. Zone Area: 4- to 20-mA signal.

f. BACnet interface converter kit supplied with refrigerant monitor to communicate with BAS.
g. Audible/Visual Output: Provide three (3) combination horn/flashing red strobes as part of the monitoring system. Horn/Strobes to be field mounted by others.

4. Detector type: Infrared non-dispersive.
5. Display: Alphanumeric.
6. Enclosure: NEMA 250 or type as required for ambient condition.
7. Alarm Output: Contact closure.
8. Calibration: Factory calibrated.

G. SOURCE QUALITY CONTROL
1. Refrigerant Monitor: Factory tested and certified.
2. Provide six(6) filters for sensing zones and ample amount of 3/8" PE tubing for field installation.

H. Alarms
1. 4 alarm points wired from monitor to the horn/strobes indicating when a leak has been detected. The monitor initiates strobe lights and alarms.
2. Monitor to also communicate active zone concentrations and alarms to the BAS through the BACnet interface.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas instruments according to the mechanical plans.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches.

3. Sensor mounting height for refrigerant monitors shall be 12” above the finished floor.

3.5 REFRIGERANT MONITORING SYSTEM

A. Install sample points in monitored area to provide accurate measurement of gas concentration.

B. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.

C. Individually install each sample point to the refrigerant monitoring system.

D. Install tubing in a minimum size of NPS 3/8.

E. Use compression fittings at connections to equipment.

F. Support refrigerant monitoring system from floor or wall. Support floor-mounted systems using a structural channel frame. Provide mounting brackets.

3.6 HYDROGEN MONITORING SYSTEM

A. Install monitor in space to provide an accurate measurement of gas concentration as indicated on the “H” drawings.

B. Support hydrogen monitoring system from wall.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.8 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.16

SECTION 230923.18 - LEAK DETECTION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Leak-detection switches.
2. Multi-zone leak-detection monitoring controllers.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Leak-detection switches.
2. Multi-zone leak-detection monitoring controllers.

B. Product Data Submittals: For each product.

1. Operating characteristics, electrical characteristics, and furnished accessories indicating control signal, default control signal with loss of power, and electrical power requirements.
2. Product description with complete technical data and product specification sheets.
3. Installation operation and maintenance instructions, including factors affecting performance.

C. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Instrumentation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and remain operational after a seismic event.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. *Provide Seismic restraints for instrumentation systems that meet or exceeds site seismic requirements below;*
   a. Seismic Design Category C
   b. Seismic Risk Category IV
   c. Seismic Use Group III
   d. Component Importance Factor, $I_p = 1.5$
   e. Component Response Modification Factor, $R_p = 1.0$
   f. Component Amplification Factor, $a_p = 2.5$
   g. Short Term Spectral Response Acceleration Factor, $S_{ds} = 12.64\ \%\ g$
   h. Long Period Spectral Response Acceleration Factor, $S_{d1} = 9.36\%\ g$
   i. Structural Safety Factor r $= 4.0$

PART 2 - PRODUCTS

2.1 LEAK-DETECTION SWITCHES

A. Point-Type, Leak-Detection Switches:

1. <Double click here to find, evaluate, and insert list of manufacturers.>
2. Source Limitations: Obtain point-type, leak-detection switches from single manufacturer.
3. Features:

   a. Alarms: Audible and visual alarm with relay output for remote indication.
   b. Operation: Alarm activation based on detection of liquid by change in resistance.

4. Performance:

a. Field Power: 24 V ac or dc.
b. Service: Water or #2 fuel oil.
c. Temperature Limits: 32 to 122 deg F.
d. Sensing Height: Adjustable.

5. Construction:

a. Electric Connection: Cable Plug-in connector or screw terminals.
b. Enclosure: Acrylic, ABS plastic or painted metal.
c. Switch Type: DPDT or SPST relay.

B. Cable-Type, Leak-Detection Switches:

1. <Double click here to find, evaluate, and insert list of manufacturers>
2. Source Limitations: Obtain cable-type, leak-detection switches from single manufacturer.
3. Control Module Features:

a. Power and alarm LEDs.
b. Alarm test switch.
c. Continuous cable integrity self-check.

4. Performance:

a. Service: Water or other conductive liquid.
b. Switch Type: DPDT.
c. Electric Connection: Screw terminals.
d. Conduit Connection: 0.5 inch.

5. Construction:

a. Control Module Enclosure: Painted metal.
b. Cable: Hydrophobic.
c. Cable Length:

1) As required by application.
2) Standard Cable Lengths: as required by application.
3) Field Extendable: Cable with connector on each end for field extension.

d. NRTL Listing: NRTL listed for application where cable is installed in air plenums.

6. Field Power: 24 V ac or 24 to 30 V dc unless otherwise required by application.
7. Non-sensing Cable: Non-sensing cable may be used to extend sensing cable length in areas where sensing is not required. Non-sensing cable is not to affect performance or accuracy of readings.

8. Accessories: Cable cross and tee cable connectors, end connectors, and attachment clips.

2.2 MULTI-ZONE LEAK-DETECTION MONITORING CONTROLLERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

1. Source Limitations: Obtain all multi-zone leak-detection monitoring controllers from single manufacturer.

B. Description: Operation as stand-alone device with operator configuring, monitoring, locating, and acknowledging leaks locally, or through connection to building control network and access through internet interface, which can display location where the alarm occurred.

C. Performance:

1. Altitude: Suitable for Project site altitude.
2. Cable Length, Maximum: 10,000 ft..
3. Cable Length, Minimum: as required by application.
4. Detection Accuracy: Within 2 ft. plus or minus 0.5 percent of cable length.
5. Detection Repeatability: Within 2 ft. plus or minus 0.25 percent of cable length.
6. Detection Response Time: Adjustable between 5 and 900 seconds, in 5 -second intervals.
7. Relative Humidity: 5 to 95 percent, noncondensing.
8. Temperature: 32 to 122 deg F.
9. Zones: Monitoring of up to 100 separate zones.

D. Enclosure: NEMA 250, Type 1.

E. Features:

1. Alarm Notifications:

a. Local Audible Alarm: 85 dBA at 2 ft. with silence feature.
b. Local visual alarms through display.
c. Remote alarm notification through interface with building control system.
d. E-mail alarm notifications.

2. Display: Color, backlit, LCD screen.
3. Logs:

a. Event Log: Last 1000 events.
b. Trend Logs: Cable current level for each of last 365 days.

4. Password Protection: Password-protected local and remote access to change configuration, but not to view operating status.

F. Remote Control Interface:

1. Hardwired Analog Points: 4 to 20 mA.
2. Hardwired Digital Points:

a. Leak Detection: 40 zones.
b. Cable Break: 40 zones.
c. Maintenance: One zone.

3. Serial Communications:

a. RS-485: BACnet MS/TP.
b. Ethernet: Modbus TCP/IP.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 LEAK-DETECTION INSTRUMENT APPLICATION

A. Leak-Detection Switches (Point Type):underground tank interstice, above ground day tank interstice, low points of double wall piping.

B. Leak-Detection Switches (Cable Type): Underground supply and return oil piping.

C. Multi-Zone Leak-Detection Monitoring Controller: Boiler and generator Fuel oil systems.

3.3 INSTALLATION, GENERAL

A. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

B. Fastening Hardware:

1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force, or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

C. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 INSTALLATION OF LEAK-DETECTION SWITCHES

A. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent movement.

B. Fasten cable-type leak detection product to floor or supporting substrate using accessory clips furnished with product or a comparable product if furnished separately. Secure clip to floor and cable according to cable installation instructions.

3.5 ELECTRICAL POWER CONNECTIONS

A. Install electrical power to field-mounted control devices requiring electrical power.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA/NEIS 1.

G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control signal wiring to field-mounted control devices.

B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire and cable is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation for applicable considerations that impact performance.

D. Apply test fluid to floor or substrate to check proper switch operation. Test fluid is to be the same as for operation.

1. For cable-type leak detectors, check multiple locations across cable length. Number of locations will increase with length of cable.

   a. Up to 20 ft. (6 m): Two, equally spaced.
   b. Up to 50 ft. (3 m): Four, equally spaced.

c. Up to 200 ft. (60 m): Six, equally spaced.
d. Up to 1000 ft. (300 m): Eight, equally spaced.
e. <**Insert test requirements**>.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. Equipment and procedures used for calibration are to meet instrument manufacturer's written instructions.
4. Provide diagnostic and test equipment for calibration and adjustment.
5. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
6. If after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
7. Comply with field-testing requirements and procedures indicated by ASHRAE's Guideline 11 in the absence of specific requirements, and to supplement requirements indicated.

B. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

C. Switches: Calibrate switches that are adjustable to make or break contact at set points indicated.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

END OF SECTION 230923.18

SECTION 230923.22 - POSITION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Position limit switches for use in direct-digital control (DDC) systems for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For position limit switches.

1. Include operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power and electrical power requirements.
2. Include product description with complete technical data and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Instrumentation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and remain operational after a seismic event.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. *Provide Seismic restraints for instrumentation systems that meet or exceeds site seismic requirements below;*
   a. *Seismic Design Category C*
   b. *Seismic Risk Category IV*
   c. *Seismic Use Group III*
   d. *Component Importance Factor,* $I_p = 1.5$
   e. *Component Response Modification Factor,* $R_p = 1.0$
   f. *Component Amplification Factor,* $a_p = 2.5$
   g. *Short Term Spectral Response Acceleration Factor,* $S_{ds} = 12.64\ \%\ g$
   h. *Long Period Spectral Response Acceleration Factor,* $S_{d1} = 9.36\%\ g$
   i. *Structural Safety Factor r* $= 4.0$

PART 2 - PRODUCTS

2.1 POSITION LIMIT SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. OMRON Corporation.
2. Honeywell
3. Allen Bradley
4. Approved equal

B. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Performance:

1. Life Expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.
2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
3. Voltage: 125-V ac or 24-V dc, as required by application.
4. Current Rating: As required by application.
5. Temperature Rise: 50 deg C.
6. Ambient Temperature: 14 to 175 deg F.
7. Ambient Relative Humidity: 35 to 95 percent.

D. Construction:

1. NEMA 250, Type 4X enclosure.

2. Switch Type: SPDT or DPDT, as required by application.
3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
4. Electrical Connection: Screw or plug-in terminals.
5. Conduit Connection: NPS 1/2.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a seismic force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.

2. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
3. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.4 INSTALLATION OF POSITION INSTRUMENTS

A. Mounting Location:

1. Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
2. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 ADJUSTMENT, CALIBRATION, AND TESTING

A. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

B. Switches: Calibrate switches to make or break contact at set points indicated.

END OF SECTION 230923.22

SECTION 230923.23 – PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.
6. Dial-type pressure gages.
7. Gage attachments.
8. Test plugs.
9. Test-plug kits.

B. Related Requirements:
1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 DEFINITIONS

A. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.

1.3 ACTION SUBMITTALS

A. Product Data:
1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.
6. Pressure Gages and Attachments.

B. Product Data Submittals: For each product.
1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

C. Shop Drawings:
1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space, showing relationship to light switches, fire alarm devices, and other installed devices.
3. Size and location of wall access panels for instruments installed behind walls.
4. Size and location of ceiling access panels for instruments installed in accessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Product Test Reports: For each product requiring test performed by manufacturer and witnessed by a qualified testing agency.

D. Source quality-control reports.

E. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Instrumentation components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and remain operational after a seismic event.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Provide Seismic restraints for instrumentation systems that meet or exceeds site seismic requirements below;
      a. Seismic Design Category C
      b. Seismic Risk Category IV
      c. Seismic Use Group III
      d. Component Importance Factor, Ip =1.5
      e. Component Response Modification Factor, Rp= 1.0
      f. Component Amplification Factor, ap = 2.5
      g. Short Term Spectral Response Acceleration Factor, Sds = 12.64 % g
      h. Long Period Spectral Response Acceleration Factor, Sd1 = 9.36% g
      i. Structural Safety Factor = 4.0

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:
   1. Instruments must operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
      a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.
   2. Instruments and accessories are to be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated ae to be housed in protective secondary enclosures. Instrument-installed location to dictate following NEMA 250 enclosure requirements:
      a. Outdoors, Protected: Type 12.
      b. Outdoors, Unprotected: Type 4X.
      c. Indoors, Heated with Filtered Ventilation: Type 2.
      d. Indoors, Heated with Nonfiltered Ventilation: Type 12.
      e. Indoors, Heated and Air-Conditioned: Type 1.
      f. Mechanical Equipment Rooms:
         1) Chiller and Boiler Rooms: Type 12.

2) Air-Moving Equipment Rooms: Type 12.
g. Localized Areas Exposed to Washdown: Type 4X.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: 4X.
j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Dwyer Instruments, Inc.
2. Insertion length to be at least 4 inches.
3. Sensor with four radial holes of 0.04-inch diameter.
4. Brass or stainless-steel construction.
5. Sensor with threaded end support, sealing washers and nuts.
6. Connection: NPS 1/4 compression fitting.
7. Suitable for flat oval, rectangular, and round duct configurations.

B. Duct Traverse Static Pressure Sensor:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Air Monitor; an ONICON Brand.
2. Sensor to traverse the duct cross section and have at least one pickup point every 6 inches along length of sensor.
3. Construct sensor of 18-gauge Type T6063-T5 extruded and anodized aluminum.
4. Sensor supported with threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at other end.
5. Mounting plate with threaded, NPS 3/8 compression fitting for connection to tubing.
6. Accuracy within 1 percent of actual operating static pressure.
7. Dual offset static sensor design to provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30-degree yaw and pitch.
8. Suitable for velocities of 100 to 10000 fpm and temperatures of up to 200 deg F.
9. Sensor air resistance to be less than 0.1 times the velocity pressure at probe-operating velocity.
10. Suitable for flat oval, rectangular, and round duct configurations.

C. Outdoor Static Pressure Sensor - Unaffected/Unimpaired by Rain and Snow:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Air Monitor; an ONICON Brand.

2. Sensor with no moving parts.
3. Operation not affected and impaired by rain and snow.
4. Sensing plates constructed of 0.1406-inch Type 316 stainless steel.
5. Accuracy within:
   a. 1 percent of the actual outdoor atmospheric pressure when subjected to varying horizontal radial wind velocities up to40 mph.
   b. 2 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to40 mph with approach angles up to 30 degrees to horizontal.
   c. 3 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to40 mph with approach angles up to 60 degrees to horizontal.
   d. Threaded, NPS 2 connection.

D. Outdoor Static Pressure Sensor - NEMA 250, Type 4X Enclosure:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Dwyer Instruments, Inc.
2. Provides average outdoor pressure signal.
3. Sensor with no moving parts.
4. NEMA 250, Type 4X enclosure.
5. Pressure Connection: Brass barbed fitting for NPS 1/4 tubing.
6. Conduit fitting around pressure fitting for sensor support and protection to pressure connection.

E. Space Static Pressure Sensor for Exposed or Suspended Mounting:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Air Monitor; an ONICON Brand.
2. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.
3. Aluminum or Stainless steel with perforations arranged to sense space static pressure. Exposed surfaces provided with brush finish.
4. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
5. Surface-mounted sensor provided with solid mounting plate intended for mount to ceiling with pressure chamber exposed to view.
6. Surface-mounted sensor with 0.125-inch fitting for exposed tubing connection.
7. Suspended sensor intended for pendent mount with pressure chamber exposed to view.
8. Suspended sensor with NPS 1/2 fitting for exposed pipe or tubing connection.

2.3 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Dwyer Instruments, Inc.
2. Diaphragm operated to actuate an SPDT snap switch.
   a. Fan safety shutdown applications: Switch with manual reset.
3. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
6. High and Low Process Connections: Threaded, NPS 1/8.
7. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 2.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4x.
   c. Hazardous Environments: Explosion proof.
8. Operating Data:
   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:
      1) Continuous: 45 inches wg.
      2) Surge: 10 psig.
   c. Temperature Limits: Minus 30 to 180 deg F.
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 3 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Ashcroft Inc.
2. Performance:
   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 0.5 percent of the span at reference temperature of 70 deg F.
   c. Hysteresis: Within 0.02 percent of the span.
   d. Repeatability: Within 0.05 percent of the calibrated span.

e. Stability: Within 0.25 percent of span per year.
f. Overpressure: 15 psig.
g. Temperature Limits: Minus 20 to 160 deg F.
h. Compensate Temperature Limits: 35 to 135 deg F.
i. Thermal Effects: 0.015 percent of full scale per degree F.
j. Warm-up Time: Within 5 seconds.
k. Response Time: 5 ms 250 ms.
l. Shock and vibration to not harm the transmitter.

3. Output Signals:
   a. Retain only one of first two subparagraphs below to restrict signal options.
   b. Analog Current Signal:
      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 1000-ohm load.
   c. Analog Voltage Signal:
      1) Three wire, zero to 10 V.
      2) Minimum Load Resistance: 1000 ohms.

4. Operator Interface:
   a. Zero and span adjustments within 10 percent of full span.
   b. Potentiometer adjustments located on face of transmitter.

5. Construction:
   a. Type 300 stainless steel enclosure.
   b. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.
   c. Screw terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 2.
   f. Mounting Bracket: Appropriate for installation.
   g. Reverse wiring protected.
   h. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

2.5 LIQUID-PRESSURE SWITCHES

A. Liquid Gauge Pressure Switch, Diaphragm Operated:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Mercoid Controls; a division of Dwyer Instruments, Inc.
   b. WIKA.
   c. Barksdale
   d.

2. Diaphragm operated to actuate a SPDT or DPDT snap switch.
3. Electrical Connections: Screw terminal.

4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Internal hex nut set-point adjustment with enclosed set-point indicator and scale.
   a. Process Connection: Threaded, NPS 1/4 or NPS 1/2.
6. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1, 12.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4X with drain.
   c. Hazardous Environments: Explosion proof.
7. Operating Data:
   a. Electrical Rating: 15 A at 120-, 240-, and 480-V ac.
   b. Pressure Limits: 1200 psig.
   c. Ambient Temperature Limits: Minus 30 to 180 deg F.
   d. Process Temperature Limits: Minus 4 to 167 deg F.
   e. Adjustable Operating Range: 20 to 250 psig.
   f. Deadband: Adjustable.
8. Pressure Chamber Material: brass or stainless steel.
9. Diaphragm Material: Buna-N or fluorocarbon.

B. Liquid Gauge Pressure Switch, Bourdon Tube Operated:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Dwyer Instruments, Inc.
   b. WIKA
   c. Bourdon USA.
   d. Requirements in remaining subparagraphs below are based on Dwyer's "Series DA, DS."
2. Description:
   a. Bourdon tube operated to actuate a SPDT or DPDT snap switch.
   b. Provide switches used in safety limiting applications with manual reset.
   c. Wetted Materials: Brass or Type 403 stainless steel or Type 316 stainless steel.
   d. Electrical Connections: Screw terminal.
   e. Enclosure Conduit Connection: Knock out or threaded connection.
   f. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
   g. Process Connection: Threaded, NPS 1/4.
   h. Enclosure:
      1) Dry Indoor Installations: NEMA 250, Type 1.
      2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
      3) Hazardous Environments: Explosion proof.
   i. Operating Data:
      1) Electrical Rating: 10 A at 120-V ac.
      2) Pressure Limits: Equal to maximum pressure in full-scale range, but not less than system design pressure rating.
      3) Temperature Limits: 180 deg F.

4) Operating Range: Approximately 2 times set point, but not less than system design pressure rating.
5) Deadband: Adjustable or fixed as required by application.

j. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Liquid-Pressure Differential Switch with Set-Point Indicator:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>Requirements in remaining subparagraphs below are based on Dwyer's "Series DP."

2. Description:
a. Brass or Type 316 stainless steel double opposing bellows operate to actuate a SPDT snap switch.
b. Electrical Connections: Screw terminal.
c. Enclosure Conduit Connection: Knock out or threaded connection.
d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
e. High and Low Process Connections: Threaded, NPS 1/8.
f. Enclosure:
1) Dry Indoor Installations: NEMA 250, Type 1.
2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
3) Hazardous Environments: Explosion proof.
g. Operating Data:
1) Electrical Rating: 15 A at 120- to 240-V ac.
2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
3) Temperature Limits: Minus 10 to 180 deg F.
4) Operating Range: Approximately 2 times set point.
5) Deadband: Adjustable or fixed as required by application.

D. Liquid-Pressure Differential Switch:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
a. Requirements in remaining subparagraphs below are based on Ashcroft's "LPA, S Series."

2. Description:
a. Type 316 stainless steel double opposing bellows operate to actuate an SPDT snap switch.
b. Wetted materials: Type 316 stainless steel.
c. First option in "Seal" Subparagraph below has process temperature limitation of 150 deg F (66 deg C).
d. Seal: Buna-N or Viton.
e. Electrical Connections: Screw terminal.
f. Enclosure Conduit Connection: Knock out or threaded connection.
g. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
h. High and Low Process Connections: Threaded, NPS 1/4.
i. Enclosure: NEMA 250, Type 4 or 4X.

j. Operating Data:
   1) Electrical Rating: 10 A at 120- to 240-V ac.
   2) Pressure Limits: Zero to 500 psig.
   3) Ambient Temperature Limits: Minus 20 to 150 deg F.
k. "Buna-N" seal has process temperature limitation of 150 deg F (66 deg C). Revise upper temperature limit in "Process Temperature Limits" Subparagraph below if using Buna-N material.
   1) Process Temperature Limits: 20 to 300 deg F.
   2) Operating Range: 2 times set point, unless otherwise required by application.
   3) Deadband: Adjustable or fixed as required by application.
l. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 LIQUID-PRESSURE TRANSMITTERS

A. Liquid Gauge Pressure Transmitter with Adjustable Span:
   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
      a. Requirements in remaining subparagraphs below are based on Rosemount's "Model 3051CG." Retain "Hazardous Classification" Subparagraph below for transmitters located in hazardous environments.
   2. Hazardous Classification: FM Approved for hazardous environments.
      a. Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, Groups A through H.
      b. Explosion proof for Class I, Division 1, Groups B, C, and D.
      c. Retain one of first two subparagraphs below.
      d. Dust ignition proof for Class II, Division 1, Groups E, F, and G.
      e. Dust ignition proof for Class III, Division 1.
   3. Performance:
      a. Range: Minus 300 to 300 psig.
      b. Span: Field adjustable.
      c. Minimum Span: 3 psig.
      d. Reference Accuracy: Within 0.07 percent of span or better.
      e. Stability: Within 0.125 percent of upper range limit for 5 years.
      f. Overpressure Limits: 3626 psig.
      g. Process Temperature Limits: Minus 40 to 250 deg F.
      h. Ambient Temperature Limits: Minus 40 to 185 deg F.
      i. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
      j. Shock and vibration must not harm the transmitter.
   4. Analog Output Current Signal:
      a. Two-wire, 4- to 20-mA dc current source.
      b. Signal capable of operating into 1000-ohm load.
      c. Digital signal based on HART protocol carried with current signal.
      d. Dampening: Field selectable from zero to 30 seconds.
   5. Operator Interface: Zero and span adjustments located behind cover.

a. Retain "Display" Subparagraph below for display.

6. Display: Digital, five-digit, two-line display with 0.4-inch-high alphanumeric characters.
7. Construction:
   a. Non-wetted parts of transmitter constructed of aluminum or stainless steel.
   b. Enclosure with removable cover on each side.
   c. Wetted parts of transmitter constructed of Type 316 stainless steel.
   d. Threaded, NPS 1/2 process connection on bottom of instrument.
   e. Drain/vent valve on process connection.
   f. Two 1/2-inch trade size conduit connections on side of instrument enclosure.
   g. Screw terminal block for wire connections.
   h. NEMA 250, Type 4X.
   i. Mounting Bracket: Appropriate for installation.

B. Liquid-Pressure Differential Transmitter:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   a. Requirements in remaining subparagraphs below are based on Dwyer's "Series 645."
2. Performance:
   a. Range: Approximately 2 times set point.
   b. Span: Adjustable plus or minus one milliamp, noninteractive.
   c. Accuracy: Within 0.25 percent of full scale.
   d. Pressure: Maximum operating pressure 2.5 times range.
   e. Temperature Limits: Zero to 175 deg F.
   f. Compensate Temperature Limits: 30 to 150 deg F.
   g. Thermal Effects: 0.02 percent of full scale per degree F.
   h. Response Time: 30 to 50 ms.
   i. Shock and vibration must not harm the transmitter.
3. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.
4. Operator Interface:
   a. Zero and span adjustments located behind cover.
   b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
5. Construction:
   a. Aluminum and stainless steel enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
   c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
   d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
   e. Screw terminal block for wire connections.
   f. NEMA 250, Type 4X.
   g. Mounting Bracket: Appropriate for installation.
   h. Retain subparagraph below for optional three-valve manifold.

6. Three-Valve Manifold: Construct manifold of brass, bronze, or stainless steel. Manifold to have threaded, NPS 1/4 process connections.

C. Liquid-Pressure Differential Transmitter - Field-Selectable Output:
   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
      a. Requirements in remaining subparagraphs below are based on Setra's "Model 230."
   2. Performance:
      a. Range: Approximately 2 times the set point.
      b. Span: Adjustable plus or minus one milliamp, noninteractive.
      c. Accuracy: Within 0.25 percent of full scale.
      d. Hysteresis: Within 0.1 percent of full scale.
      e. Repeatability: Within 0.05 percent of full scale.
      f. Maximum Working Pressure: 250 psig.
      g. Temperature Limits: Zero to 175 deg F.
      h. Compensate Temperature Limits: 30 to 150 deg F.
      i. Thermal Effects: 0.02 percent of full scale per degree F.
      j. Response Time: 30 to 50 ms.
      k. Shock and vibration must not harm the transmitter.
      l. Retain one of first two subparagraphs below to restrict signal options.
   3. Analog Output Current Signal:
      a. Two-wire, 4- to 20-mA dc current source.
      b. Signal capable of operating into 1000-ohm load.
   4. Analog Output Voltage Signal:
      a. Three wire, zero to 10 V.
      b. Minimum Load Resistance: 1000 ohms.
   5. Operator Interface:
      a. Zero and span adjustments located behind cover.
      b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
   6. Construction:
      a. Aluminum and stainless steel enclosure with removable cover.
      b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
      c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
      d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
      e. Screw terminal block for wire connections.
      f. NEMA 250, Type 4.
      g. Mounting Bracket: Appropriate for installation.
      h. Retain subparagraph below for optional three-valve manifold.
   7. Provide transmitter with three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Provide manifold with NPS 1/4 NPT process connections.

D. Liquid-Pressure Differential Transmitter with Field-Selectable Range and Display:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   a. Requirements in remaining subparagraphs below are based on Dwyer's "Series WWDP."
2. Performance:
   a. Field-Selectable Range:
   b. Retain one of first three subparagraphs below.
      1) 5, 10, 25, 50 psig.
      2) 10, 20, 50, 100 psig.
      3) 25, 50, 125, 250 psig.
   c. Field-selectable unidirectional or bidirectional range.
   d. Accuracy: Within 1 percent of the full-scale range, except lowest selectable range within 2 percent.
   e. Stability: Within 0.5 percent of span per year.
   f. Pressure: Maximum operating pressure equal to highest pressure in range.
   g. Overpressure: Proof pressure 2.2 times full scale; burst pressure 40 times full scale.
   h. Temperature Limits: Minus 44 to 185 deg F.
   i. Compensate Temperature Limits: 32 to 130 deg F.
   j. Thermal Effects: 2 percent of full scale per 100 deg F.
   k. Response Time: Field selectable from 1 to 5 seconds.
   l. Shock and vibration must not harm the transmitter.
3. Configurable Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.
4. Configurable Analog Output Voltage Signals:
   a. Three wire, zero to 5 V, zero to 10 V, and 1 to 5 V.
   b. Minimum Load Resistance: 1000 ohms.
   c. Retain "Display" Subparagraph below for optional display.
5. Display: Four-digit LCD with minimum 0.4-inch-high numeric characters.
6. Operator Interface:
   a. Digital zero button located behind cover.
   b. Range selector located behind cover.
7. Construction:
   a. Cast-aluminum enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH stainless steel.
   c. Threaded, NPS 1/8 process connections on bottom of instrument enclosure.
   d. 1/2-inch trade size connection for conduit on bottom of instrument enclosure.
   e. Screw terminal block for wire connections.
   f. Vertical plane mounting.
   g. NEMA 250, Type 4.
   h. Mounting Bracket: Appropriate for installation.

E. Liquid-Pressure Differential Transmitter with Field-Selectable Range:
   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

a. Requirements in remaining subparagraphs below are based on MAMAC's "PR-283."

2. Performance:
   a. Field-Selectable Ranges:
   b. Retain one of first three subparagraphs below.
      1) 5, 10, 20 psig.
      2) 25, 50, 100 psig.
      3) 75, 150, 300 psig.
   c. Accuracy: Within 1 percent of the full-scale range.
   d. Static Pressure: 2 times full-scale range.
   e. Overpressure: Proof pressure 3 times full-scale range, burst pressure 5 times full scale.
   f. Compensate Temperature Limits: Zero to 180 deg F.
   g. Thermal Effects: 0.025 percent of full scale per degree F.
   h. Shock and vibration must not harm the transmitter.
   i. Retain one of first two subparagraphs below to restrict output signal.
3. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.
4. Analog Output Voltage Signals:
   a. Three wire, field selectable from zero to 5 V or zero to 10 V.
   b. Minimum Load Resistance: 1000 ohms.
5. Operator Interface:
   a. Zero button located behind cover.
   b. Range selector located behind cover.
6. Construction:
   a. 0.0478-inch-thick, corrosion-resistant steel enclosure with baked-enamel finish.
   b. Removable front cover.
   c. Wetted parts of transmitter constructed of 17-4 PH stainless steel.
   d. Threaded, NPS 1/8 process connections on bottom of instrument enclosure.
   e. 1/2 inch trade size conduit on side of instrument enclosure.
   f. Screw terminal block for wire connections.
   g. Vertical plane mounting.
   h. NEMA 250, Type 4.
   i. Mounting Bracket: Appropriate for installation.
   j. Retain first subparagraph below for optional three-valve manifold.
7. Provide transmitter with three-valve manifold.
   a. Construct manifold of Type 316 stainless steel.
   b. Manifold with threaded, NPS 1/4 process connections.

2.7 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AMETEK, Inc.; U.S. Gauge.
b. Ashcroft Inc.
c. Trerice, H. O. Co.
d. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
e. Weiss Instruments, Inc.
f. WIKA Instrument Corporation - USA.
g. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel ; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   a. Match pressure connection size in first subparagraph below with gage attachment size.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 , ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi .
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.8 GAGE ATTACHMENTS

A. Match attachment size in three paragraphs below with pressure-gage-connection size.

B. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston -type surge-dampening device. Include extension for use on insulated piping.

C. Siphons: Loop-shaped section of brass or stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

D. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.9 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Trerice, H. O. Co.
   2. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   3. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.10 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Trerice, H. O. Co.
2. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
3. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing one pressure gage and adapter, and carrying case. Pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig .

D. Carrying Case: Metal or plastic, with formed instrument padding.

2.11 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PRESSURE INSTRUMENT APPLICATIONS

A. Duct-Mounted Static Pressure Sensors:
   1. Indicated on Drawings: Duct insertion static pressure sensor.

B. Space Static Pressure Sensors:
   1. Indicated on Drawings: Space static pressure sensor for wall mounting.

C. Air-Pressure Differential Switches:
   1. Indicated on Drawings: Air-pressure differential switch.

D. Air-Pressure Differential Transmitters:
   1. Indicated on Drawings: Air-pressure differential transmitter.
   2.

E. Liquid-Pressure Differential Switches:

   1. Chilled water System, pump proof of flow differential pressure: Liquid-pressure differential switch with set-point indicator.
   2. Chilled water Heat Recovery System, chilled water pump proof of flow differential pressure: Liquid-pressure differential switch with set-point indicator.
   3. Chilled water System, heat recovery pump proof of flow differential pressure: Liquid-pressure differential switch with set-point indicator.
   4. Heating Hot water System, pump proof of flow differential pressure: Liquid-pressure differential switch with set-point indicator.
   5. Heating Hot water System, boiler proof of flow differential pressure: Liquid-pressure differential switch with set-point indicator.

F. Liquid-Pressure Differential Transmitters:

   1. Chilled water System, Chiller evaporator differential pressure flow transmitter: Liquid-pressure differential transmitter with adjustable span
   2. Condenser Water System, Condenser water differential pressure flow transmitter: Liquid-pressure differential transmitter.
   3. Heat Recovery Chilled water System, Chiller evaporator differential pressure flow transmitter: Liquid-pressure differential transmitter with adjustable span
   4. Heat Recovery Chiller Condenser Water System, Condenser water differential pressure flow transmitter: Liquid-pressure differential transmitter. System:

5. Chilled water System, Chilled water supply and return differential pressure transmitter: Liquid-pressure differential transmitter with adjustable span
6. Heating Hot water System, Heating Hot water supply and return differential pressure transmitter: Liquid-pressure differential transmitter with adjustable span
7. Chilled water System, Chilled water expansion tank pressure transmitter: Liquid-pressure transmitter with adjustable span
8. Heating Hot water System, Heating Hot water expansion tank pressure transmitter: Liquid-pressure transmitter with adjustable span

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a seismic force.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install gages adjacent to machines and equipment to allow service and maintenance of gages, machines, and equipment.

H. Adjust faces of gages to proper angle for best visibility.

I. Install valve and snubber in piping for each pressure gage for fluids (except steam).

J. Install valve and syphon fitting in piping for each pressure gage for steam.

K. Install test plugs in piping tees.

L. Install pressure gages in the following locations:
1. Inlet and discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller evaporator and condenser connection.
3. Inlet and outlet of each plate and frame heat exchanger.
4. Inlet and outlet of each mixing valve.
5. Suction and discharge of each pump.
6. At each hydronic expansion tank.
7. At each makeup water station.
8. At inlet and outlet of each strainer or filter (both hydronic and air). Pressure gauges for strainers and filters may be differential type.
9. Inlet and outlet of each hydronic coil.
10. Where indicated on the drawings and plans.

3.4 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.5 INSTALLATION OF PRESSURE INSTRUMENTS

A. Mounting Location:
1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to

accommodate field mounting. Securely support and brace products to prevent vibration and movement.

6. Install instruments (except pressure gauges) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:

Indicated locations of sensors on Drawings.

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 75 percent of distance of longest hydraulic run. Location of sensors to be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

Indicated locations of sensors on Drawings.

1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.

3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 10 feet; otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:
1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection to be full size of switch connection, but not less than NPS 1/2. Install stainless steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:
1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection to be full size of switch connection, but not less than NPS 1/2. Install stainless steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.

8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
   1. Sealed, direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:
   1. Liquid-filled, direct-mounted, metal case.

C. Pressure gages at suction and discharge of each pump shall be one of the following:
   1. Liquid-filled, direct -mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0-200 psig

B. Scale Range for Condenser-Water Piping: 0 to 200 psig

C. Scale Range for Heating Hot-Water Piping: 0 to 160 psig

D. Scale Range for Low Pressure Steam and condensate Piping: 0 to 30 psig

E. Scale Range for Medium Pressure Steam and condensate Piping: 0 to 100 psig

F. Scale range for pumped steam condensate piping : 0-160 psig

G. Scale range for fuel oil piping: 0-50 psig

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.9 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:
1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration to comply with instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent to be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:
1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:
1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.11 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.12 MAINTENANCE SERVICE

Verify, with Owner, that maintenance service is required for Project.

A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by skilled employees of systems and equipment Installer. Include semiannual preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies to be manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner has right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.23

SECTION 230923.27 - TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Combination air temperature sensors and switches.
3. Air temperature switches.
4. Air temperature RTD transmitters.
5. Liquid and steam temperature sensors, high-end commercial grade.
6. Liquid and steam temperature sensors, industrial grade.
7. Liquid and steam temperature transmitters, high-end commercial grade.
8. Liquid and steam temperature transmitters, industrial grade.
9. Light-activated thermometers.
10. Thermowells.
11. Test plugs.
12. Test-plug kits.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 DEFINITIONS

A. HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

B. RTD: Resistance temperature detector.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Air temperature sensors.

2. Combination air temperature sensors and switches.
3. Air temperature switches.
4. Air temperature RTD transmitters.
5. Liquid and steam temperature sensors, high-end commercial grade.
6. Liquid and steam temperature sensors, industrial grade.
7. Liquid and steam temperature transmitters, high-end commercial grade.
8. Liquid and steam temperature transmitters, industrial grade.
9. Light-activated thermometers.
10. Thermowells.
11. Test plugs.
12. Test-plug kits.

B. Product Data Submittals: For each product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
3. Sizes and locations of wall access panels for instruments installed behind walls.

4. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Product Test Reports: For each product requiring test performed by manufacturer and witnessed by a qualified testing agency.

D. Field quality-control reports.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Provide two matching product(s) in Project inventory for each unique size and type.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic Performance: instrumentation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and remain operational after a seismic event.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. *Provide Seismic restraints for instrumentation components that meet or exceeds site seismic requirements below;*
   a. Seismic Design Category C
   b. Seismic Risk Category IV
   c. Seismic Use Group III
   d. Component Importance Factor, I_p = 1.5
   *e. Component Response Modification Factor, **R_p= 1.0***
   *f. Component Amplification Factor, **a_p = 2.5***
   *g. Short Term Spectral Response Acceleration Factor, **S_{ds} = 12.64 % g***
   *h. Long Period Spectral Response Acceleration Factor, **S_{d1} = 9.36% g***
   *i. Structural Safety Factor **= 4.0***

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 12.
    b. Outdoors, Unprotected: Type 4X.
    c. Indoors, Heated with Filtered Ventilation: Type 2.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
    e. Indoors, Heated and Air Conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: Type 12.
        2) Air-Moving Equipment Rooms: Type 12.

    g. Localized Areas Exposed to Washdown: Type 4X.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
    i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
    j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common requirements:

1. 100 or 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F.
    b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
    c. Repeatability: Within 0.5 deg F.
    d. Self-Heating: Negligible.

4. Transmitter Requirements:

    a. Transmitter required for each 100-ohm RTD.
    b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Minco.
    b. Approved equal
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F.
4. Probe: Single-point sensor with a stainless steel sheath.
5. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches long.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch trade size.

C. Platinum RTD, Air Temperature Averaging Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Minco.
    b. Approved equal
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F.
4. Multiple sensors to provide average temperature across entire length of sensor.
5. Rigid probe of aluminum, brass, copper, or stainless steel sheath.
6. Flexible probe of aluminum, brass, copper, or stainless steel sheath and formable to a 4-inch radius.
7. Length: As required by application to cover entire cross section of air tunnel.
8. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
9. Gasket for attachment to duct or equipment to seal penetration airtight.
10. Conduit Connection: 1/2-inch trade size.

D. Platinum RTD Outdoor Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Minco.
    b. Approved equal
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F.
4. Probe: Single-point sensor with a stainless steel sheath.
5. Solar Shield: Stainless steel.
6. Enclosure: NEMA 250, Type 4X junction box or combination conduit and outlet box with removable cover and gasket.
7. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Minco.
    b. Approved equal
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 212 deg F.
4. Sensor assembly shall include a temperature sensing element mounted under a flush, brushed-aluminum cover.
5. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
6. Concealed wiring connection.

F. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

1. 100- or 1000-ohm platinum RTD.

2. Temperature Transmitter Requirements:

    a. Mating transmitter required with each 100-ohm RTD.
    b. Mating transmitters optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

3. Provide digital display of sensed temperature.
4. Provide sensor with local control.

    a. Local override to turn HVAC on.
    b. Local adjustment of temperature set point.
    c. Both features shall be capable of manual override through control system operator.

2.3 COMBINATION AIR TEMPERATURE SENSORS AND SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Minco.
2. Approved equal

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. Combination temperature sensor and switch in same instrument.

D. Air Temperature Switch:

1. Factory preset set point of 38 deg F. Field-adjustable set point from 30 to 44 deg F.
2. Responsive to coldest 12-inch section of sensor length.
3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual rest at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.

E. Air Temperature Sensor:

1. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
2. Platinum RTD with a value of 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Accuracy: Within 0.9 deg F.
4. Output Signal: 4 to 20 mA for connection to remote monitoring.
5. Encase RTDs in a flexible nominal 0.375-inch-diameter sheath constructed of brass.
6. Lead wires shall be 18-gage AWG copper.
7. Enclosure: NEMA 250, Type 4.

2.4 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Honeywell International Inc.
b. Siemens Industry, Inc., Building Technologies Division.

c. Approved equal

2. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

a. Operating Temperature Range: 15 to 55 deg F.
b. Temperature Differential: 5 deg F, non-adjustable and additive.
c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
d. Sensing Element Maximum Temperature: 250 deg F.
e. Voltage: 120-V ac.
f. Current: 16 FLA.
g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.

4. Construction:

a. Vapor-Filled Sensing Element: Nominal 20 ft. long.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch trade size.

2.5 AIR TEMPERATURE RTD TRANSMITTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Minco.
2. Approved equal

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. House electronics in NEMA 250 enclosure.

1. Duct: Type 12.
2. Outdoor: Type 4X.
3. Conditioned Space: Type 1.
4. Un-Conditioned Space: Type 2.

D. Conduit Connection: 1/2-inch trade size.

E. Functional Characteristics:

1. Input:

a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):

a. Space: 40 to 90 deg F.
b. Supply Air Cooling and Heating: 40 to 120 deg F.
c. Supply Air Cooling Only: 40 to 90 deg F.
d. Supply Air Heating Only: 40 to 120 deg F.
e. Exhaust Air: 50 to 100 deg F.
f. Return Air: 50 to 100 deg F.
g. Mixed Air: Minus 40 to 140 deg F.
h. Outdoor: Minus 40 to 140 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together.

F. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.6 LIQUID AND STEAM TEMPERATURE SENSORS, HIGH-END COMMERCIAL GRADE

A. RTD, High-End Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Minco.
b. Approved Equal.

2. Resistance temperature sensors shall comply with IEC 60751, Class B requirements.

3. Platinum with a value of 100 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
4. Encase RTD in a Type 316 stainless steel sheath with a 0.25-inch OD.
5. Provide [**two**] [**three**] [**four**]-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.
6. Provide spring-loaded RTDs for thermowell installations.
7. Performance Characteristics:

    a. Range: Minus 328 to 932 deg F.
    b. Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.
    c. Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F.
    d. Hysteresis: Within 0.04 percent of range.
    e. Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps.

B. Thermowells, High-End Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. Minco.
    b. Approved Equal

2. Stem: Straight or stepped or tapered shank formed from solid bar stock.
3. Material: Type 304 or Type 316 stainless steel.
4. Process Connection: Threaded, NPS 3/4.
5. Sensor Connection: Threaded, NPS 1/2.
6. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
7. Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
8. Length: As required by application and pipe size.
9. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

C. Connection Heads, High-End Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Minco.
    b. Approved equal
2. Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
3. Terminals: Six or eight as required by sensor.
4. Conduit Connection: 1/2-inch trade size.
5. Sensor Connection: NPS 1/2.

D. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

2.7 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Honeywell International Inc.
    b. Approved equal
2. Description:

    a. Two-position control.
    b. Field-adjustable set point.
    c. Manual reset.
    d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

    a. Operating Temperature Range: 65 to 250 deg F.
    b. Temperature Differential Deadband: 5 to 30 deg F, adjustable.
    c. Enclosure Ambient Temperature: 150 deg F.
    d. Sensing Element Pressure Rating: 250 psig.
    e. Voltage: 120-V ac.
    f. Current: 8 FLA.
    g. Switch Type: SPDT snap switch.

4. Construction:

    a. Vapor-Filled Immersion Element: Copper, nominal 3 inches long.
    b. Temperature Scale: Fahrenheit, visible on face.
    c. Set-Point Adjustment: Screw.
    d. Enclosure: Painted metal, NEMA 250, Type 1.
    e. Electrical Connections: Screw terminals.
    f. Conduit Connection: 3/4-inch trade size.

2.8 LIQUID AND STEAM TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Minco.

2. Approved equal

B. House electronics in NEMA 250, Type 4 or Type 4X enclosure.

C. Enclosure Connection: 1/2-inch trade size.

D. Functional Characteristics:

1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-wire sensors.
2. Default Span (Adjustable):

a. Chilled Water: Zero to 100 deg F.
b. Condenser Water: Zero to 150 deg F.
c. Heating Hot Water: 32 to 250 deg F.
d. Heat Recovery: Zero to 250 deg F.
e. Steam: 32 to 400 deg F.
f. Steam Condensate: 32 to 250 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

E. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.9 LIGHT-ACTIVATED THERMOMETERS

A. Direct-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

a. Trerice, H. O. Co.
b. Weiss Instruments, Inc.
c. WIKA Instrument Corporation - USA.
d. Winters Instruments - U.S.

2. Case: Metal ; 9-inch nominal size unless otherwise indicated.
3. Scale(s): Deg F and deg C.

4. Case Form: Adjustable angle .
5. Connector: 1-1/4 inches , with ASME B1.1 screw threads.
6. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

7. Display: Digital.
8. Accuracy: Plus or minus .5 deg F.

B. Remote-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

    a. Miljoco Corporation.
    b. Weiss Instruments, Inc.
    c. Winters Instruments - U.S.

2. Case: Plastic, for wall mounting.
3. Scale(s): Deg F and deg C.
4. Sensor: Bulb and thermister wire.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

5. Display: Digital.
6. Accuracy: Plus or minus .5 deg F.

2.10 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.11 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR .
4. Material for Use with Steel Piping: CRES .
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.

7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.12 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trerice, H. O. Co.
2. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
3. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F .

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.13 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

1. Trerice, H. O. Co.
2. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
3. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing one thermometer(s), adapter, and carrying case. Thermometer sensing elements and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F .

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F .

E. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:

1. Duct,: 1000-ohm platinum RTD.
2. Outdoor,: 1000-ohm platinum RTD.
3. Space,: 1000-ohm platinum RTD.

B. Air Temperature Transmitters:

1. Duct,: Air temperature RTD transmitter.
2. Outdoor,: Air temperature RTD transmitter.
3. Space, Air temperature RTD transmitter.

C. Liquid and Steam Temperature Sensors:

1. CWS and CWR System: Liquid and steam temperature sensor, high-end commercial grade .

2. CTWS and CTWR System: Liquid and steam temperature sensor, high-end commercial grade.

3. HHWS and HHWR System: Liquid and steam temperature sensor, high-end commercial grade.

4. Steam and condensate System: Liquid and steam temperature sensor, high-end commercial grade.

D. Liquid and Temperature Transmitters:

1. CHWS and CHWR System: Liquid temperature transmitter, commercial grade .

2. CTWS and CTWR System: Liquid temperature transmitter, commercial grade.

3. HHWS and HHWR System: Liquid temperature transmitter, commercial grade.

4. Steam and Condensate System: Liquid and steam temperature transmitter, commercial grade.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a20 kN force.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

F. Install thermometers adjacent to machines and equipment to allow service and maintenance of thermometers, machines, and equipment.

G. Adjust faces of thermometers to proper angle for best visibility.

H. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

I. Install thermowells with extension on insulated piping.

J. Fill thermowells with heat-transfer medium.

K. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

L. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

M. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

N. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic coil.
2. Inlet and outlet of each hydronic boiler.
3. Evaporator and condenser inlets and outlets of each chiller.
4. Inlets and outlets of each heat exchanger.
5. Inlets and outlet of each mixing valve
6. Inlet and outlet of each hydronic coil in air-handling units.
7. In each air handler outside air, return air, and supply air duct.
8. Before and after piping junctions as indicated on drawings.
9. Adjacent to each temperature transmitter.

3.4 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.5 INSTALLATION OF TEMPERATURE INSTRUMENTS

A. Mounting Location:

1. Roughing In:

a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
2) Do not begin installation without submittal approval of mounting location.

c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Installation of Space Temperature Sensor:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Installation of Outdoor Air Temperature Sensor:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Installation of Single-Point Duct Temperature Sensor:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Installation of Averaging Duct Temperature Sensor:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.

3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Installation of Low-Limit Air Temperature Switch:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Installation of Liquid Temperature Sensor:

1. Assembly shall include sensor, thermowell and connection head.
2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4:

    a. Install reducers to increase pipe size to NPS 4 at point of thermowell installation.
    b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
    c. Minimum insertion depth shall be 2-1/2 inches.

4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor, service platform or catwalk.

3.6 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic boiler are to be the following:
1.
2. Direct-mounted, light-activated type.
3. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlets and outlets of each chiller are to be the following:
   1.
   2. Direct-mounted, light-activated type.
   3. Test plug with EPDM self-sealing rubber inserts.

C. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems are to be the following:
   1. Direct-mounted, light-activated type.
   2. Test plug with EPDM self-sealing rubber inserts.

D. Thermometers at inlets and outlets of each hydronic heat exchanger are to be the following:
   1.
   2. Direct-mounted, light-activated type.
   3. Test plug with EPDM self-sealing rubber inserts.

E. Thermometers at outside-, return-, supply-, and mixed-air ducts are to be the following:
   1. Direct-mounted, light-activated type.

F. Thermometer stems are to be of length to match thermowell insertion length.

3.7 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping:
   1. 0 to 150 deg F

B. Scale Range for Condenser-Water Piping:

   1. 0 to 150 deg F

C. Scale Range for Heating, Hot-Water Piping:

   1. 0 to 250 deg F and 0 to 150 deg C.

D. Scale Range for Steam and Steam-Condensate Piping:
   1. 50 to 400 deg F and 0 to 200 deg C.

E. Scale Range for Air Ducts:
   1. Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.9 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.10 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.11 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform according to manufacturer's written instruction.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Prepare test and inspection reports.

3.13 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.14 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of systems and equipment Installer. Include semiannual preventive maintenance, repair or replacement of worn or defective components, cleaning and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.15 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.27

SECTION 230923.33 - VIBRATION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Mechanical vibration switches.
2. Electronic vibration switches.
3. Combination vibration switch and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 DEFINITIONS

A. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Mechanical vibration switches.
2. Electronic vibration switches.
3. Combination vibration switch and transmitters.

B. Product Data Submittals: For each product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power, calibration data specific to each unique application, and electrical power requirements.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions including factors affecting performance.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring and cable.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Vibration Instruments shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and remain operational after a seismic event.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. *Provide Seismic restraints for instrumentation systems that meet or exceeds site seismic requirements below;*
   a. Seismic Design Category C
   b. Seismic Risk Category IV
   c. Seismic Use Group III
   d. Component Importance Factor, $I_p = 1.5$
   e. Component Response Modification Factor, $R_p = 1.0$
   f. Component Amplification Factor, $a_p = 2.5$
   g. Short Term Spectral Response Acceleration Factor, $S_{ds} = 12.64\ \%\ g$
   h. Long Period Spectral Response Acceleration Factor, $S_{d1} = 9.36\%\ g$
   i. Structural Safety Facto **= 4.0**

PART 2 - PRODUCTS

2.1 MECHANICAL VIBRATION SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Metrix Instrument Co.
2. Robertshaw

3. Murphy

B. Description: Inertia-sensitive armature mechanism trips on high vibration and operates snap action switch.

C. Performance:

1. Frequency Range: Zero to 3600 rpm.
2. Vibration Range: Zero to 10 g.
3. Temperature Limits: Minus 40 to 158 deg F.
4. Electrical Rating: 15 A at 125- or 480-V ac.
5. Switch Type: DPDT snap switch.
6. Start Delay: 20 to 30 seconds, by applying reset voltage at start signal to prevent switch from tripping.

D. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Groups B, C, and D; Class II, Groups E, F, and G.

E. Operator Interface:

1. Vibration Set-Point Adjustment: Zero to 100 percent of range.
2. Push-button reset on switch face and reset coil for remote reset.

F. Enclosure Construction:

1. Cast aluminum.
2. NEMA 250, Type 4 or Type 4X.
3. Electrical Connection: Screw terminals.
4. Conduit Connection: 3/4-inch trade size.

2.2 ELECTRONIC VIBRATION SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Metrix Instrument Co.
2. Robertshaw
3. Murphy

B. Description:

1. Accelerometer-based velocity response.
2. Single set point.

C. Performance:

1. Frequency Range: 3 to 500 Hz.
2. Vibration Range: Zero to 1.0 inch per second.
3. Temperature Limits: Minus 4 to 167 deg F.
4. Electrical Rating: 5-A inductive, 60-A surge for one cycle; normally open-triac leakage is 10 mA.
5. Trip Logic: Field-selectable, normally open-/normally closed-triac, non-latching, automatic reset.
6. Start Trip Timer: 30 seconds.
7. Monitor Trip Delay: 3 seconds.

D. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Groups C and D; Class II, Groups E, F, and G.

E. Operator Interface:

1. Vibration Set-Point Adjustment: Externally adjustable with tamperproof gradual dial.
2. Trip Indicator: Flashing red LED.
3. Digital Display: 2.5-digit numerical display of vibration level.

F. Enclosure Construction:

1. Cast aluminum.
2. Screw-on cover.
3. NEMA 250, Type 4.
4. Electrical Connection: Two wires, 24 inches long.
5. Conduit Connection: 1/2-inch trade size, sealed entry.
6. Flange mounting adapter, as applicable.

2.3 COMBINATION VIBRATION SWITCH AND TRANSMITTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Metrix Instrument Co.
2. Robertshaw

B. Description:

1. Input sensitivity.
2. Full-scale vibration range.
3. Mode: Peak or rms.
4. Trip delay.
5. Start delay.
6. Relay State: Latching or non-latching.

7. Relay: Non-energized, normally open or energized, normally closed.

C. Accelerometer integral to unit with capability of multiple remote sensor inputs.

1. Instrument furnished with programming and setup software.

D. Performance:

1. Frequency Range for Integral Accelerometer: 2 to 1000 Hz.
2. Ambient Temperature Limits: Minus 40 to 185 deg F.
3. Humidity: 100 percent condensing.

E. Analog Output Current Signal:

1. Two-wire, 4- to 20-mA dc current source.
2. Signal capable of operating into 1000-ohm load.

F. Digital Output Signal: Dual relay(s).

G. Operator Interface:

1. USB or keypad configurable.
2. Digital Display: Two lines of display.

H. Enclosure Construction:

1. Cast aluminum.
2. Screw-on cover.
3. NEMA 250, Type 4X.
4. Electrical Connection: Screw terminals.
5. Conduit Connection: 3/4-inch trade size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION INSTRUMENT APPLICATIONS

A. Cooling tower: Combination switch and transmitter.

B.

3.3 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

C. Properly support instrument wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to excessive force.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration are to comply with instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments are to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Switches: Calibrate switches to make or break contact at set points indicated.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 230923.33

SECTION 230923.43 - WEATHER STATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Weather stations connected to direct-digital controls for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 DEFINITIONS

A. I/O: Input/output.

B. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

C. RS-485: A TIA standard for multipoint communications using two twisted pairs.

1.3 ACTION SUBMITTALS

A. Product Data: For weather stations, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating control signal over range, electrical power requirements, and limitations of ambient operating environment including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For weather stations to include in operation and maintenance manuals.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Hydronic piping shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and remain operational after a seismic event.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. *Provide Seismic restraints for piping systems that meet or exceeds site seismic requirements below;*
   a. Seismic Design Category C
   b. Seismic Risk Category IV
   c. Seismic Use Group III
   d. Component Importance Factor, ***I_p = 1.5***
   e. Component Response Modification Factor, ***R_p= 1.0***
   f. Component Amplification Factor, ***a_p = 2.5***
   g. Short Term Spectral Response Acceleration Factor, ***S_{ds} = 12.64 % g***
   h. Long Period Spectral Response Acceleration Factor, ***S_{d1} = 9.36% g***
   i. Structural Safety factor ***= 4.0***

PART 2 - PRODUCTS

2.1 WEATHER STATIONS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. WeatherHawk.

B. Description:

1. Weather station shall measure and record wind speed and direction, air temperature and relative humidity, barometric pressure, solar radiation, and rain.
2. Design weather station for applications with minimal visual impact, high reliability, and a long interval between routine servicing.
3. Weather station shall use solid-state sensors with no moving parts.
4. Weather station shall not be impaired by heavy snowfall or freezing conditions that produce rime ice. Provide a thermostatically controlled heater element in the sensor head that keeps the wind sensor elements and the precipitation sensor surface free of snow and ice to minus 62 deg F.
5. Weather station shall directly connect to host device, or wirelessly connect to a host device through a fully integrated, industrial-grade, 916-MHz spread spectrum radio-frequency communications technology. Where required by application, replace 916-MHz radio-frequency components with 922-MHz and 2.4-GHz radio-frequency components to comply with local, regional, and national radio-frequency licensing requirements.
6. RS-232 serial data I/O shall be located on the bottom of the weather station and used as a second serial communications port, for programming and testing the system, or for direct data downloads using a personal computer or personal digital assistant.
7. Weather station shall be provided with a mounting system supplied by weather station manufacturer that is suitable for the installation.

C. Sensor Technology:

1. Wind speed and direction shall use acoustic techniques. Sensor shall consist of three equally spaced ultrasonic transducers in a horizontal plane. Values of any two array paths shall enable computation of both wind speed and direction, and a signal processing technique shall enable the measurement to be calculated using the two array paths of the best quality.
2. Rain shall be measured using a stainless steel piezometric impact surface that counts the raindrops and measures their acoustic signature, integrating that information to provide a near-real-time value for rainfall amount and rate.
3. Barometric pressure, relative humidity, air temperature, and solar radiation measurements shall be made by scientific grade sensors.

4. Air-temperature and relative-humidity sensors shall be combined in an integrated, user-replaceable unit that requires no calibration.

    a. Relative humidity sensor shall be a thin-polymer, capacitive sensor.
    b. Air-temperature sensor shall be a capacitive ceramic sensor.

5. Barometric pressure shall be measured with a capacitive silicon, temperature-corrected, strain gage.
6. Solar radiation shall be measured by a silicon pyranometer with a cut filter limiting the spectral exposure to the 300- to 1100-nm wavelength.

D. Performance:

1. Air Temperature:

    a. Range: Minus 60 to 140 deg F.
    b. Accuracy: Within 0.9 deg F.
    c. Resolution: 0.1 deg F.

2. Relative Humidity:

    a. Range: Zero to 100 percent.
    b. Accuracy: Within 3 percent over the range of zero to 90 percent and within 5 percent between 90 to 100 percent.
    c. Resolution: 0.1 percent.

3. Barometric Pressure:

    a. Range: 17.72- to 32.48-in. Hg.
    b. Accuracy: 0.015-in. Hg between 32 to 86 deg F.
    c. Resolution: 0.03-in. Hg between minus 60 to 140 deg F.

4. Solar Radiation:

    a. Spectral Range: 300 to 1100 nm.
    b. Reproducibility: Within 2 percent.
    c. Output: 0.2 mV per watts per square meters.
    d. Range: Zero to 1000 W per square meters.
    e. Temperature Range: Minus 40 to 130 deg F.

5. Rain:

    a. Collecting Area: 9.3 sq. in..
    b. Range: Zero to 7.87 inches per hour.
    c. Accuracy: Within 5 percent.
    d. Resolution: 0.001 inch.

6. Wind Direction:

    a. Azimuth: Zero to 360 degrees.
    b. Response Time: 250 ms.
    c. Accuracy: Within 2 degrees.
    d. Resolution: 1 degree.

7. Wind Speed:

    a. Range: Zero to 134 mph.
    b. Response Time: 0.25 second.
    c. Accuracy: Greater of 0.67 mph or 2 percent.
    d. Resolution: 0.22 mph.

8. Data Storage: 60 days of hourly data.

E. Output Signals:

1. RS-232 or RS-485 serial interface directly from weather station to host.
2. In applications that cannot accept a serial signal, provide a serial-to-analog converter.
3. Serial-to-Analog Converter:

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

        1) Nokeval Oy.
    b. Serial converter designed to add analog outputs for measuring instruments that have only serial output.
    c. Configure to give analog outputs from all measuring sensors and calculated parameters.
    d. Each converter shall have four analog outputs with a 4- to 20-mA signal.
    e. Provide multiple converters for applications requiring more points.
    f. Converter requires a 24-V dc power supply.

F. Communication Interface:

1. Weatherproof serial cables shall be used to connect the RS-232 I/O on the weather station. Cables shall use nickel-plated brass DB-9 connectors for corrosion resistance and include a Sanoprene jacket suitable for both high-ultraviolet and direct-burial environments.
2. An RF4xx spread spectrum radio-frequency transceiver shall be provided with every wireless weather station.

G. Unit shall be provided with a 120-V ac, 60-Hz power supply, a serial cable, and an antenna.

H. Software:

1. Data Transfer Protocols, Software, and Data Interface Hardware: Weather stations that communicate using a proprietary protocol shall be provided with a software development kit to enable a qualified software developer in development of software drivers for third-party devices or software.
2. Manufacturer shall submit description and pricing information of software application offerings for weather station management, data acquisition and logging, report generation, and data display for review and consideration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF WEATHER STATIONS

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support weather station, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to forces that are consistent with building code structural design requirements.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

3.3 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.5 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each weather station installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment used for calibrating. Submit procedures before calibration and adjustment.
3. For each analog signal, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed weather stations shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed weather station with a signal accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each weather station according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

3.8 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain weather stations.

B. Provide a complete set of instructional videos covering each product specified and installed and showing the following:

1. Software programming.
2. Calibration and test procedures.
3. Operation and maintenance requirements and procedures.
4. Troubleshooting procedures.

C. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

D. Record videos on DVD disks.

E. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.43

SECTION 231113 - FACILITY FUEL-OIL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED REQUIREMENTS

A. Section 312000 – Earth Moving

1.3 SUMMARY

A. Section Includes:

1. Fuel-oil pipes, tubes, and fittings.
2. Double-containment pipe and fittings.
3. Piping specialties.
4. Joining materials.
5. Specialty valves.
6. Mechanical leak-detection valves.
7. Leak detection and monitoring system.
8. Labels and identification.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Fuel-oil pipes, tubes, and fittings.
2. Double-containment pipe and fittings.
3. Piping specialties.
4. Joining materials.
5. Specialty valves.
6. Mechanical leak-detection valves.
7. Leak-detection and monitoring system.
8. Labels and identification.

B. Product Data Submittals:

1. Include construction details, material descriptions, and dimensions of individual components and profiles.

2. Include rated capacities, pressure ratings, operating characteristics, electrical characteristics, settings, and furnished specialties and accessories.

C. Shop Drawings: For fuel-oil piping.

1. Include plans, elevations sections, hangers, and supports for multiple pipes.
2. Include details of location of anchors, alignment guides, and expansion joints and loops.
3. Scale: 1/4 inch per foot.

D. Delegated-Design Submittal: For fuel-oil piping, supports, and seismic restraints indicated to comply with performance requirements and design criteria.

1. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Detail fabrication and assembly of anchors and seismic restraints.
3. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Detail fabrication and assembly of pipe anchors, hangers, supports for multiple pipes, and attachments of the same to building structure.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plans and details, drawn to scale, on which fuel-oil piping is shown and coordinated with other installations, using input from installers of the items involved.
2. Site Survey: Plans, drawn to scale, on which fuel-oil piping and tanks are shown and coordinated with other services and utilities.

B. Welding certificates.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-oil equipment and accessories to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.8 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.

D. Store PE pipes and valves protected from direct sunlight.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of flexible, double-containment piping and related equipment that fail in materials or workmanship within specified warranty period.

1. Failures due to defective materials or workmanship for materials including piping, dispenser sumps, water-tight sump entry boots, terminations, and other end fittings.
2. Warranty Period: 30 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.

C. Fuel-Oil Valves: Comply with UL 842 and have service mark initials "WOG" permanently marked on valve body.

D. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil piping.

2.2 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 100-psig maximum fuel-oil supply pressure.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design restraints and anchors and multiple pipe supports and hangers for fuel-oil piping.

C. Seismic Performance: Fuel-oil piping and associated components to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment".

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5

2.3 FUEL-OIL PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
    e. Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. Double-Containment Piping - Rigid:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Conley Composites; an Andronaco Industries Co.
    b. Franklin Fueling Systems.
    c. NOV Inc.
    d. PermAlert.
    e. Smith Fiberglass; a National Oilwell Varco brand.
    f. Tricon Piping Systems, Inc.

2. Source Limitations: Obtain double-containment piping - rigid, from single manufacturer.
3. Standard: Comply with UL 971.
4. RTRP: ASTM D2996 or ASTM D2997 carrier and containment piping and mechanical couplings to seal carrier and containment piping or individually bonded joints.

    a. Minimum Operating-Pressure Rating for RTRP NPS 2 and NPS 3 (DN 50 and DN 80): 150 psig.
    b. Minimum Operating-Pressure Rating for RTRP NPS 4 and NPS 6 (DN 100 and DN 150): 125 psig. Compliance with UL 971 is not required for NPS 6 and larger piping.
    c. Fittings: RTRF complying with ASTM D2996 or ASTM D2997 and made by RTRP manufacturer; watertight sump entry boots, termination, or other end fittings.

5. Leak-Detection System: Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

2.4 PIPING SPECIALTIES

A. Metallic Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. American Flexible Hose Co., Inc.
    b. Flexicraft Industries.
    c. FLEX-ING, Inc.
    d. Hose Master, Inc.
    e. Metraflex Company (The).
    f. Proco Products, Inc.
    g. Tru-Flex Metal Hose Corp.

2. Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.

3. Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
4. Minimum Operating Pressure: 150 psig.
5. End Connections: Socket, flanged, or threaded end to match connected piping.
6. Maximum Length: 30 inches
7. Swivel end, 50-psig maximum operating pressure.
8. Factory-furnished anode for connection to cathodic protection.

B. Isolation valves:

1. Body: ASTM A 216 Class 150 carbon steel Grade WCB with bolted cover and carbon steel Grade B7 bolts/nuts.
2. End Connections: Socket weld ends.
3. Ball: ASTM A 276 Type 316
4. Seat Material: PTFE
5. Stem Packing: carbon filled PTFE.
6. CWP Rating: 285 psig @ -20 to 100^{o}F.

C. Y-Pattern Strainers:

1. Body: ASTM A 216 Class 150 carbon steel Grade WCB with bolted cover and bottom drain connection.
2. End Connections: Flanged or socket weld ends.
3. Strainer Screen: 80-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 285 psig @ -20 to 100^{o}F.

D. Basket Strainers:

1. Body: ASTM A216 Class 150 carbon steel Grade WBC with bolted cover and bottom drain connection.
2. End Connections: flanged or socket weld ends.
3. Strainer Screen: 80-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 285 psig @ -20 to 100^{o}F.

E. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

F. Camlock Fittings
1. Type A, meeting the requirements of commercial items description A-A-59326 fittings, 2” in diameter, 304 SS construction. Gasketing to be BUNA-N fuel rated materials.

2.5 JOINING MATERIALS

A. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

B. Bonding Adhesive for RTRP and RTRF: As recommended by piping and fitting manufacturer.

2.6 SPECIALTY VALVES

A. Pressure Relief Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. Anderson Greenwood; Pentair, Ltd.
    b. Fulflo Specialties, Inc.
    c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
    d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.
2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body: cast steel.
4. Springs: Stainless steel, interchangeable.
5. Seat and Seal: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Maximum Inlet Pressure: 150 psig.
9. Relief Pressure Setting: 60 psig.

B. Oil Safety Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. Anderson Greenwood; Pentair, Ltd.
    b. Fulflo Specialties, Inc.
    c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
    d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.
2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body:cast steel.
4. Springs: Stainless steel.
5. Seat and Diaphragm: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Manual override port.
9. Maximum Inlet Pressure: 60 psig.

10. Maximum Outlet Pressure: 3 psig.

C. Emergency Shutoff Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. EMCO Wheaton.
   b. Franklin Fueling Systems.
   c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Single poppet valve.
4. Body: ASTM A 126, cast iron.
5. Disk: FPM.
6. Poppet Spring: Stainless steel.
7. Stem: Plated brass.
8. O-Ring: FPM.
9. Packing Nut: PTFE-coated brass.
10. Fusible link to close valve at 165 deg F.
11. Thermal relief to vent line pressure buildup due to fire.
12. Air test port.
13. Maximum Operating Pressure: 0.5 psig.

2.7 MECHANICAL LEAK-DETECTION VALVES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Franklin Fueling Systems.
2. Red Jacket Pumps.

B. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

C. Body: ASTM A 126, cast iron.

D. O-Rings: Elastomeric compatible with fuel oil.

E. Piston and Stem Seals: PTFE.

F. Stem and Spring: Stainless steel.

G. Piston Cylinder: Burnished brass.

H. Indicated Leak Rate: Maximum 3 gph at 10 psig.

I. Leak Indication: Reduced flow.

2.8 LEAK-DETECTION AND MONITORING SYSTEM

A. Cable and Sensor System: Comply with UL 1238.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Caldwell Systems Corporation.
b. Containment Solutions, Inc.
c. Franklin Fueling Systems.
d. Gems Sensors & ControlsInc.
e. Highland Tank & Manufacturing Company, Inc.
f. INCON, Inc.
g. In-Situ, Inc.
h. MSA Instrument Division.
i. Pentair Thermal Management.
j. Perma-Pipe, Inc.
k. Veeder-Root Company (The).

2. Calibrated leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil piping.
3. Include fittings and devices required for testing.

2.9 LABELS AND IDENTIFICATION

A. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and other conditions affecting performance of fuel-oil piping.

B. Examine installation of fuel-burning equipment and fuel-handling and storage equipment to verify actual locations of piping connections before installing fuel-oil piping.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PREPARATION

A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.4 OUTDOOR PIPING INSTALLATION

A. Underground Fuel-Oil Piping Burial Depth:

1. Under Compacted Backfill: [**18 inches**] <**Insert dimension**> below finished grade.
2. Under Asphalt 2 Inches (51 mm) Thick: 8 inches below bottom of asphalt.
3. Under 4 Inches (102 mm) of Reinforced Concrete in Areas Subject to Vehicle Traffic: 4 inches below bottom of concrete.
4. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

B. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer. Review protective coating damage with Architect prior to repair.
3. Replace pipe having damaged PE coating with new pipe.

C. Install double-containment, fuel-oil pipe at a minimum slope of 1 percent downward toward fuel-oil storage tank.

D. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.

E. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.

F. Install metal pipes and tubes, fittings, valves, and flexible connectors at piping connections to AST.

G. Install fittings for changes in direction in rigid pipe.

H. Install system components with pressure rating equal to or greater than system operating pressure.

I. Terminate fill piping with a male camlock connection, suitable for commercial truck dispensing. Provide dust cap to prevent dirt/moisture instruction during periods of inactivity.

3.5 INDOOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction to allow for mechanical installations.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings at a height that allows sufficient space for ceiling panel removal.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Comply with requirements for equipment specifications for roughing-in requirements.

I. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.

J. Prohibited Locations:

1. Do not install fuel-oil piping in or through HVAC ducts and plenums, chimneys or gas vents (flues), ventilating ducts, or elevator shafts.
2. Do not install fuel-oil piping within solid walls or partitions.

K. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

L. Connect branch piping from top or side of horizontal piping.

M. Install unions in pipes NPS 2 and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.

N. Do not use fuel-oil piping as grounding electrode.

O. Install sleeves and sleeve seals for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

3.6 VALVE INSTALLATION

A. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.

B. Install valves in accessible locations.

C. Install oil safety valves at inlet of each oil-fired appliance.

D. Install pressure relief valves in distribution piping between the supply and return lines.

E. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping. Comply with requirements in Section 230523.12 "Ball Valves for HVAC Piping."

F. Install manual air vents at high points in fuel-oil piping.

G. Install emergency shutoff valves at dispensers.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.
   1. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

D. Flanged Joints: Install gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.

3.8 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for hangers, supports, and anchor devices specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting and coupling.

E. Support vertical runs of steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.9 LEAK-DETECTION AND MONITORING SYSTEM INSTALLATION

A. Install tank leak-detection and monitoring system. Install alarm panel inside building where indicated.

B. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes at low points in piping.

3.10 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

B. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.

C. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

D. Connect piping to equipment with shutoff valve and union. Install union between valve and equipment.

E. Install flexible piping connectors at final connection to burners, oil-fired appliances, and day tanks.

3.11 LABELING AND IDENTIFYING

A. Nameplates, pipe identification, valve tags, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.

1. Text: In addition to identifying unit, distinguish between multiple units; inform operator of operational requirements; indicate safety and emergency precautions; and warn of hazards and improper operations.

C. Install detectable warning tape directly above fuel-oil piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.

1. Piping: Over underground fuel-oil distribution piping.

3.12 FIELD QUALITY CONTROL

A. Pressure Test Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:

1. Fuel-Oil Distribution Piping: Minimum 60 psig for minimum 30 minutes.
2. Fuel-Oil, Double-Containment Piping:

    a. Carrier Pipe: Minimum 60 psig for minimum 30 minutes.
    b. Containment Conduit: Minimum 5 psig for minimum 60 minutes.

3. Suction Piping: Minimum 20-in. Hg for minimum 30 minutes.
4. Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed 10 psig.

B. Fuel oil piping system to be cleaned using compressed air. Connect sections of piping to a compressed air source. Piping section shall be configured to as to not damage any equipment by passing mil scale through the devise. Blow clean until no visible mil scale/rust is visible in the air stream exiting the pipe.

C. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.

D. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.

E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Bleed air from fuel-oil piping using manual air vents.

G. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.13 OUTDOOR PIPING SCHEDULE

A. All underground fuel-oil piping is to be installed in containment piping.

B. Underground Fuel-Oil Piping: Rigid, double-containment piping. Size indicated is carrier-pipe size.

C. Underground fuel-oil-tank fill and vent piping to be the following:

1. NPS 2 (DN 50) Pipe Size and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints. Coat pipe and fittings with protective coating for steel piping.
2. NPS 2-1/2 (DN 65) Pipe Size and Larger: Steel pipe, steel welding fittings, and welded joints. Coat pipe and fittings with protective coating for steel piping.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Aboveground fuel-oil piping shall be the following:

1. All fuel oil piping: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.

3.14 INDOOR PIPING SCHEDULE

A. All indoor, aboveground fuel-oil piping shall be installed in containment piping. Material to be the following:

1. All fuel oil piping Steel pipe, steel fittings, and welded or flanged joints.

B. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

END OF SECTION 231113

SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Joining materials.
4. Manual gas shutoff valves.
5. Motorized gas valves.
6. Earthquake valves.
7. Pressure regulators.
8. Service meters.
9. Dielectric fittings.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. An example includes rooftop locations.

C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

D. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Piping specialties.
2. Corrugated, stainless steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Service meters. Indicate pressure ratings and capacities. Include bypass fittings and meter bars supports.
6. Dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Certificates:

1. Welding certificates.

C. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

D. Field Quality-Control Submittals:

1. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Qualifications:

1. Steel Support Welding: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding: Qualify procedures and operators in accordance with the ASME Boiler and Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping in accordance with requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.8 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide purging and startup of natural-gas supply in accordance with requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed and concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

C. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 220553 "Identification of Plumbing Piping and Equipment."

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each product type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Comply with the International Fuel Gas Code.

B. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 65 psig minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: 5 psig.

C. Natural-Gas System Pressure within Buildings:
1. Two pressure ranges. Primary pressure is 5 psig, and is reduced to secondary pressure of more than 0.5 psig, but not more than 2 psig.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Seismic Performance: Natural-gas piping system is to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

1. The term "withstand" means "the piping system will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the piping system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

2.3 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum O-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless-steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Baker Hughes Company.
        2) Smith-Blair, a Xylem brand.

    b. Steel flanges and tube with epoxy finish.
    c. NBR seals.

d. Steel bolts, washers, and nuts.
e. Coupling is to be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
f. Steel body couplings installed underground on plastic pipe are to be factory equipped with anode.

2.4 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated, stainless steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches.

B. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

E. Weatherproof Vent Cap:

1. Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.5 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.6 MANUAL GAS SHUTOFF VALVES

A. See "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves NPS 1-1/4 to NPS 2 having initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
4. Service Mark: Initials "WOG" permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A.Y. McDonald Mfg. Co.
    b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
    c. BrassCraft Manufacturing Co.; a Masco company.
    d. Perfection Corporation.
    e. R.W. Lyall; brand of Hubbell Utility Solutions; Hubbell Incorporated.

2. Body: Bronze, complying with ASTM B584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A.Y. McDonald Mfg. Co.
    b. Lee Brass Company.

2. Body: Bronze, complying with ASTM B584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A.Y. McDonald Mfg. Co.
    b. Mueller Co. LLC; Mueller Water Products, Inc.
    c. XOMOX; Crane ChemPharma & Energy.

2. Body: Cast iron, complying with ASTM A126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A.Y. McDonald Mfg. Co.
    b. Homestead Valve: a division of Olson Technologies, Inc.
    c. Milliken Valve Company; a Mueller brand.
    d. Mueller Co. LLC; Mueller Water Products, Inc.

2. Body: Cast iron, complying with ASTM A126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.7 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton.
    b. Honeywell Building Solutions; Honeywell International, Inc.
    c. Johnson Controls, Inc.

2. Body: Brass or aluminum.
3. Seats and Disc: NBR.
4. Springs and Valve Trim: Stainless steel.
5. Normally closed.
6. Visual position indicator.
7. Mechanical actuator operated by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eclipse Innovative Thermal Technologies.
    b. Magnatrol Valve Corporation.
    c. WATTS; A Watts Water Technologies Company.

2. Pilot operated.
3. Body: Brass or aluminum.
4. Seats and Disc: NBR.
5. Springs and Valve Trim: Stainless steel.
6. 120 V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.
8. Normally closed.
9. Visual position indicator.

2.8 EARTHQUAKE VALVES

A. Earthquake Valves, Maximum Operating Pressure of 5 psig: Comply with ASCE/SEI 25.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Firefighter Gas Safety Products.
    b. Pacific Seismic Products, Inc.

2. Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure: 5 psig.
4. Cast-aluminum body with nickel-plated chrome steel internal parts.
5. NBR valve washer.
6. Sight windows for visual indication of valve position.
7. Threaded end connections complying with ASME B1.20.1.

8. Wall-mounting bracket with bubble level indicator.

B. Earthquake Valves, Maximum Operating Pressure of 60 psig: Comply with ASCE/SEI 25.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Pacific Seismic Products, Inc.

2. Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure: 60 psig.
4. Cast-aluminum body with stainless steel internal parts.
5. NBR, reset-stem O-ring seal.
6. Valve position, open or closed, indicator.
7. Composition valve seat with clapper held by spring or magnet locking mechanism.
8. Level indicator.
9. End Connections: Threaded for valves NPS 2 and smaller; flanged for valves NPS 2-1/2 and larger.

2.9 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Actaris: a brand of ITT Controls.
b. American Meter Company.
c. Fischer; Emerson Electric Co., Automation Solutions.
d. Itron Inc.
e. Richards Industrials.
f. Schneider Electric USA, Inc.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.

7. Seal Plug: UV-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to regulator.
9. Pressure regulator is to maintain discharge pressure setting downstream and is to not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: Field verify.

C. Line Pressure Regulators: Comply with ANSI Z21.80A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Actaris: a brand of ITT Controls.
    b. American Meter Company.
    c. Dormont; A Watts Water Technologies Company.
    d. Fischer; Emerson Electric Co., Automation Solutions.
    e. Itron Inc.
    f. Maxitrol Company.
    g. Richards Industrials.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: UV-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to regulator.
9. Pressure regulator is to maintain discharge pressure setting downstream and is to not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig.

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Dormont; A Watts Water Technologies Company.
    b. Eaton.
    c. Harper Wyman Co.
    d. Maxitrol Company.

2. Body and Diaphragm Case: Die-cast aluminum.

3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: NBR.
6. Seal Plug: UV-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 5 psig.

2.10 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. A.Y. McDonald Mfg. Co.
   b. Capitol Manufacturing Company.
   c. GF Piping Systems: Georg Fischer LLC.
   d. WATTS; A Watts Water Technologies Company.
   e. Wilkins.
   f. Zurn Industries, LLC.

2. Description:

   a. Standard: ASSE 1079.
   b. Pressure Rating: 125 psig minimum at 180 deg F.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Capitol Manufacturing Company.
   b. GF Piping Systems: Georg Fischer LLC.
   c. Matco-Norca.
   d. WATTS; A Watts Water Technologies Company.
   e. Wilkins.

2. Description:

   a. Standard: ASSE 1079.
   b. Factory-fabricated, bolted, companion-flange assembly.

c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, LLC.
b. CALPICO, Inc.
c. GF Piping Systems: Georg Fischer LLC.
d. GPT; a division of EnPRO Industries.

2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

2.11 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description and rated pressure of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

B. Label and identify gas piping and pressure outside a multitenant building by tenant.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping in accordance with the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the International Fuel Gas Code requirements for preventing accidental ignition.

3.3 INSTALLATION OF OUTDOOR PIPING

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.

D. Install fittings for changes in direction and branch connections.

E. Install pressure gauge upstream and downstream from each service regulator. Pressure gauges are specified in Section 230519 "Meters and Gauges for HVAC Piping."

3.4 INSTALLATION OF INDOOR PIPING

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Do not install piping in concealed locations unless sleeved with the sleeve open at both ends.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Where installing piping above accessible ceilings, allow sufficient space for ceiling panel removal.

G. Locate valves for easy access. Do not locate valves within return air plenums.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
2. Install sediment trap on both sides of regulators for gas reduction to 2 psig with valve and capped.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gauge upstream and downstream from each line regulator. Pressure gauges are specified in Section 230519 "Meters and Gauges for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.5 INSTALLATION OF SERVICE-METER ASSEMBLIES

A. Install service-meter assemblies aboveground, on concrete bases.

B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

3.6 INSTALLATION OF VALVES

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

F. Do not install valves in return-air plenums.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.8 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for hangers, supports, and anchor devices.

C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for corrugated stainless steel tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within 12 inches of each fitting.

F. Support vertical runs of steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs of corrugated stainless steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.9 PIPING CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas-appliance equipment grounding conductor of the circuit powering the appliance in accordance with NFPA 70.

C. Where installing piping adjacent to appliances, allow space for service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

3.10 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.11 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base in accordance with seismic codes at Project. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Use 3000 psig, 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.12 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Test, inspect, and purge natural gas in accordance with the International Fuel Gas Code and authorities having jurisdiction.
2. Natural-gas piping will be considered defective if it does not pass tests and inspections.

B. Prepare test and inspection reports.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.14 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping is to be one of the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
2. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping is to be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller is to be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping is to be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping is to be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.
3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
4. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground portion of vent pipe and fittings with protective coating for steel piping.

3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

A. Aboveground, branch piping NPS 1 and smaller is to be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping is to be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with steel welding fittings and welded joints.

C. Underground, below building, piping is to be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.
3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
4. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground portion of vent pipe and fittings with protective coating for steel piping.

3.17 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES EQUAL TO OR MORE THAN 5 PSIG

A. Aboveground Piping: Maximum operating pressure more than 5 psig.

B. Aboveground, Branch Piping: Steel pipe with steel welding fittings and welded joints.

C. Aboveground, distribution piping is to be the following:

1. Steel pipe with steel welding fittings and welded joints.

D. Underground, below building, piping is to be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.
3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
4. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground portion of vent pipe and fittings with protective coating for steel piping.

3.18 UNDERGROUND, MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground:
1. PE valves.
2. NPS 2 and Smaller: Bronze plug valves.
3. NPS 2-1/2 and Larger: Cast-iron, lubricated plug valves.

3.19 ABOVEGROUND, MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter are to be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter are to be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller are to be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger are to be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

E. Valves in branch piping for single appliance are to be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 231123

SECTION 231213 - FACILITY FUEL-OIL PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Duplex fuel-oil pumps.
2. Fuel-oil polishing systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include, where applicable, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fuel-oil pumps and fuel-oil polishing systems.

1. Include construction details and dimensions of individual components for fuel-oil pumps.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Scale: 1/4 inch per foot.

C. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data.

1. Detail fabrication and assembly of anchors and seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication and assembly of hangers, supports, and attachments of the same to building structure.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For fuel-oil pumps, and fuel-oil polishing systems, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-oil pumps and fuel-oil maintenance systems to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.7 WARRANTY

A. Manufacturer Warranty: Manufacturer and installer agree to repair or replace fuel-oil pumps and fuel-oil polishing systems that fail in materials or workmanship within specific warranty period.

B. Warranty Period for Fuel-Oil Pumps: Three years from date of Substantial Completion.

C. Warranty Period for Fuel-Oil Polishing Systems: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 100-psig fuel-oil maximum supply pressure

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design restraint and anchors for fuel-oil

pumps, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Seismic Performance: Factory-installed support attachments for pumpsare to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Component Importance Factor: 1.5.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

2.2 DUPLEX FUEL-OIL TRANSFER PUMP SETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Earthsafe Systems, Inc.
2. Flo Fab Inc.
3. Preferred Utilities Manufacturing Corp.
4. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.

B. Description: Comply with HI 3.1-3.5.

1. Type: Positive-displacement, rotary type.
2. Impeller: Steel gear with crescent.
3. Housing: Cast-iron foot mounted.
4. Bearings: Bronze, self-lubricating.
5. Shaft: Polished steel.
6. Seals: Mechanical.
7. Base: Steel.
8. Pressure Relief: Built in.
9. Discharge Check Valve: Built in.

C. Drive: Direct close coupled.

D. Controls:

1. Maintain minimum manifold pressure with outdoor-air temperature less than 55 deg F.
2. Seven-day schedule.

3. Stage multiple pumps to maintain pressure at a common supply manifold.
4. Alternate pumps to equalize run time.
5. Alarm motor failure.
6. Manual reset dry-run protection.
7. Stop pumps if fuel level falls below pump suction.
8. De-energize and sound alarm for pump, locked-rotor condition.
9. Sound alarm for open circuit and for high and low voltage.
10. Lights shall indicate normal power on, run, and off conditions.
11. Interface with automatic control system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:

    a. Start/stop pump set when generators start, and day tank level control.
    b. Operating status.
    c. Alarm off-normal status.

E. Piping Furnished with Pumps: Steel with ferrous fittings and threaded or welded joints. Match piping and components specified in section 231113 – “Facility Fuel Oil Piping”.

F. Strainers Furnished with Pumps: Duplex, basket type with corrosion-resistant-metal-screen baskets. Provide a minimum 1.2 mm opening strainer baskets and three (3) sets of start-up socks for initial start-up.

G. Capacities and Characteristics:

1. See Schedule in drawing set for pump sizes, capacities, motor horsepower, and electrical characteristics.

2.3 FUEL-OIL POLISHING SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Earthsafe Systems, Inc.
2. Fuel Technologies, International, LLC.
3. Fueltec Systems, LLC.
4. Preferred Utilities Manufacturing Corporation.

B. Source Limitations: Obtain fuel-oil polishing system from single manufacturer.

C. Description: Factory-fabricated and -wired, fuel-oil polishing system for fuel-oil filtration; with enclosure, filter, fuel-oil pump, and controls.

1. System to be FM Global approved and be listed and labeled an NRTL acceptable to authorities having jurisdiction.
2. Enclosure: NEMA 250, Type 3R, painted steel containing pumps, filters, accessories, and controls. Hinged door on the front of enclosure.

3. Pump: Comply with HI 3.1-3.5, steel gear with crescent, positive-displacement, direct-coupled, rotary type.
4. Materials: Cast-iron housing; bronze bearings; steel shaft; mechanical seals; and built-in, pressure relief bypass valve.
5. Piping: Steel with malleable-iron fittings and threaded joints or wrought-steel fittings and welded joints.
6. Multiple-Tank Manifolds:

    a. Manifold fabricated of Schedule 80, black steel pipe and threaded nipples for three tanks.
    b. Solenoid valves for supply and return piping to each tank.
    c. Strainers for each tank supply connection.

7. Programmable Logic Controller:

    a. Provide fully automatic operation of system.
    b. Alarm on maximum 15 in. Hgvacuum at pump suction indicating plugged filter.
    c. Alarm on high water level in filter.
    d. Alarm on leak in enclosure.
    e. Touchscreen; with minimum 2-line, 20-character, illuminated digital display.
    f. Display pressure differential across filter.
    g. Display pressure differential across coalescer.
    h. Controller strip heater with thermostat.

8. Fuel-Quality Analyzer: Continuously monitors fuel quality to detect and record particulate contamination and presence of water.
9. Interface with automatic control system is specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:

    a. Start/stop system when required by schedule.
    b. Operating status.
    c. Alarm off-normal status.

D. Pump Capacities and Characteristics:

1. Capacity (Each Pump): 20 gpm.
2. Maximum Suction Lift: 25 ft..
3. Inlet and Outlet Size: 1-1/2”.
4. Motor Horsepower (Each Pump): ¾ hp.
5. Electrical Characteristics (Pump Set):

    a. Volts: 120.
    b. Phase: Single.
    c. Hertz: 60.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for fuel-oil pumps to verify actual locations of pump connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.3 FUEL-OIL PUMP INSTALLATION

A. Transfer Pumps:

1. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
2. Set pumps on and anchor to concrete base.
3. Pump Mounting:

a. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
b. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Install two-piece, full-port ball valves at suction and discharge of pumps. Comply with requirements in Section 231113 "Facility Fuel-Oil Piping."

C. Install mechanical leak-detector valves at pump discharge.

D. Install duplex strainer on inlet side of fuel-oil pumps.

E. Install check valve on discharge of fuel-oil pumps.

F. Install suction piping with minimum fittings and change of direction.

G. Install vacuum and pressure gage, upstream and downstream, respectively, at each pump to measure the differential pressure across the pump. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 INSTALLATION OF FUEL-OIL POLISHING SYSTEMS

A. Polishing System Mounting:

1. Install equipment cabinet on cast-in-place concrete equipment base. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.5 LABELING AND IDENTIFYING

A. Install nameplates and signs on each fuel-oil pump. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment."

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Start fuel-oil transfer pumps and fuel-oil polishing system pumps to verify for proper operation of pump, rotation and check for leaks.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Replace strainer socks multiple times as needed until the strainer socks show no signs of debris captured.

C. Fuel-oil pumps and fuel-oil polishing systems will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fuel-oil pumps and fuel-oil polishing systems.

END OF SECTION 231213

SECTION 231313 - FACILITY UNDERGROUND FUEL-OIL STORAGE TANKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Composite, steel, fuel-oil USTs.
2. Liquid-level gage systems.
3. Leak-detection systems.
4. Fuel oil.

1.3 DEFINITIONS

A. FPM: Vinylidene fluoride-hexafluoropropylene copolymer rubber.

B. FRP: Glass-fiber-reinforced plastic.

C. UST: Underground storage tank.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include, where applicable, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Leak-detection and monitoring system.

B. Shop Drawings: For underground fuel-oil storage tanks.

1. Include plans, elevations, sections, and ballast pads and anchors, and lifting or supporting points.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Shop Drawing Scale: 1/4 inch per foot.

1.5 INFORMATIONAL SUBMITTALS

A. Site Survey: Plans, drawn to scale, on which underground fuel-oil storage tanks are shown and coordinated with other services and utilities.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: trained and certified by the tank manufacturer.

B. Underground Fuel-Oil Storage Tanks: Comply with requirements of the EPA and of state and local authorities having jurisdiction, including recording fuel-oil storage tanks.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-oil storage tanks that fail in materials or workmanship within specified warranty period.

1. Storage Tanks:

a. Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding 150 deg F:

1) Structural failures including cracking, breakup, and collapse.
2) Corrosion failure including external and internal corrosion of steel tanks.

b. Warranty Period: 30 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 COMPOSITE, STEEL, FUEL-OIL UST

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Hall Tank Co.
2. Highland Tank.
3. Lannon Tank Corporation.
4. Modern Welding Company, Inc.
5. Watco Tanks, Inc.

B. Description: UL 58, double-wall, horizontal, composite tank; with coating complying with UL 1746 and STI F894.

1. Containment Method: STI F894, Type II, with interstitial space.

C. Construction: Fabricated with welded steel and factory coating according to UL 1746 and STI F894; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:

1. Depth of Bury: 60 inches from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb.

D. Capacities and Characteristics:

1. Capacity: 50,000 Gal.
2. Diameter: 12 feet.
3. Length: 59 feet 6 inches
4. Connection Sizes:

a. Fill Line: 4”.
b. Vent Line: 4”
c. Outlet: 4”
d. Return: 4”
e. Gage: 2”

5. Fuel-Oil Grade Number: Grade No. 2.

2.2 FUEL-OIL UST ACCESSORIES

A. Tank Manholes: 22-inch-minimum diameter; bolted, flanged, and gasketed, with extension collar; for access to inside of tank.

B. Threaded pipe connection fittings on top of tank for fill, supply, return, vent, sounding, and gaging; in locations and of sizes indicated. Include cast-iron plugs for shipping.

C. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.

D. Lifting Lugs: For handling and installation.

E. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches above tank bottom and cut at a 45-degree angle.

F. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches above tank bottom and cut at a 45-degree angle.

G. Containment Sumps: Fiberglass or PE with sump base, add-on extension pieces as required, sump top, lid, and gasket-seal joints. Include sump entry boots for pipe penetrations through sidewalls.

H. Sump Entry Boots: Two-part pipe fitting for field assembly and of size required to fit over pipe. Include gaskets shaped to fit sump sidewall, sleeves, seals, and clamps as required for liquid-tight pipe penetrations.

I. Anchor Straps: Storage tank manufacturer's standard anchoring system, with straps, strap-insulating material, cables, and turnbuckles; of strength at least one and one-half times maximum uplift force of empty tank without backfill in place.

J. Overfill Prevention Valves: Factory fabricated or shop or field assembled from manufacturer's standard components. Include drop tube, cap, fill nozzle adaptor, check valve mechanism or other devices, and vent if required to restrict flow at 95 percent of tank capacity and to provide complete shutoff of filling at 98 percent of tank capacity.

2.3 LIQUID-LEVEL GAGE SYSTEM

A. Description: Calibrated, liquid-level gage system complying with UL 180 with floats or other sensors and remote annunciator panel.

B. Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons, and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.

C. Controls: Electrical, operating on 120-V ac.

2.4 LEAK-DETECTION AND MONITORING SYSTEM

A. Cable and Sensor System: Comply with UL 1238.
   1. Calibrated, leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
   2. Include fittings and devices required for testing.

3. Controls: Electrical, operating on 120-V ac.
4. Calibrated, liquid-level gage complying with UL 180 with floats or other sensors and remote annunciator panel.
5. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons, and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
6. Controls: Electrical, operating on 120-V ac.

2.5 FUEL OIL

A. Fuel Oil: ASTM D396, Grade No. 2.

2.6 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

2.7 SOURCE QUALITY CONTROL

A. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, according to ASME and the following:

1. Horizontal, Steel USTs with the STI-P3 Corrosion-Protection System: UL 58 and STI P3.
2. Composite and Jacketed, Steel USTs: UL 58.
3. FRP USTs: UL 1316.

B. Affix standards organization's code stamp.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for underground fuel-oil storage tanks to verify actual locations.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

B. Excavate to sufficient depth for a minimum of 60 inches of earth cover from top of tank to finished grade. Allow for cast-in-place, concrete-ballast base plus 6 inches of sand or pea gravel between ballast base and tank. Extend excavation at least 12 inches around perimeter of tank. See drawings for additional tank depth information and detail on base.

C. Backfill excavation with clean sand or pea gravel in 12-inch lifts and tamp backfill lift to consolidate.

D.

3.3 FUEL-OIL UST INSTALLATION

A. Set tie-down eyelets for hold-down straps in concrete-ballast base and tie to reinforcing steel.

B. Place 6 inches of clean sand or pea gravel on top of concrete-ballast base.

C. Set tank on fill materials and install hold-down straps.

D. Connect piping.

E. Install tank leak-detection and monitoring devices.

F. Install containment sumps.

G. Install steel USTs with the STI-P3 corrosion-protection system according to STI R821 and STI R891. Protect anodes during tank placement and backfilling operations.

H. Install composite, steel USTs according to STI R913 and STI R891.

I. Install jacketed, steel USTs according to STI R923 and STI R891.

3.4 LIQUID-LEVEL GAGE SYSTEM INSTALLATION

A. Install liquid-level gage system. Install panel inside building where indicated.

3.5 LEAK-DETECTION AND MONITORING SYSTEM INSTALLATION

A. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.

1. Double-Wall, Fuel-Oil Storage Tanks: Install probes or use factory-installed integral probes in interstitial space.
2. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes in fuel-oil storage tank containment sumps and at low points in piping.
3. Install liquid-level gage.

3.6 LABELING AND IDENTIFYING

A. Nameplates, pipe identification, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."

B. Install detectable warning tape directly above UST, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

1. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.
2. Install over edges of each UST.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:

a. Double-Wall Tanks:

1) Inner Tanks: Minimum 3 psig and maximum 5 psig.
2) Interstitial Space: Minimum 3 psig and maximum 5 psig, or 5.3-in. Hg vacuum.

b. Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than 10 psig, hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
c. Maintain the test pressure for one hour.

B. USTs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 231313

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1.2 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Plastic pipe and fittings. Piping joining materials.
4. Transition fittings.
5. Dielectric fittings.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.

B. Sustainable Design Submittals:

1. Environmental Product Declaration: For each product.
2. Health Product Declaration: For each product.
3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.

C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.

4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 200 psig at 250 deg F .
2. Chilled-Water Piping: 250 psig at 100 deg F.
3. Condenser-Water Piping: 200 psig at 150 deg F.
4. Condensate-Drain Piping: 150 psig at 200 deg F.
5. Blowdown-Drain Piping: Equal to the pressure and temperature of the piping system to which it is attached.

6. Air-Vent Piping: Equal to the pressure and temperature of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

B. Seismic Performance: Hydronic piping shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. *Provide Seismic restraints for piping systems that meet or exceeds site seismic requirements below;*
   a. Seismic Design Category C
   b. Seismic Risk Category IV
   c. Seismic Use Group III
   d. Component Importance Factor, ***I_p = 1.5***
   e. Component Response Modification Factor, ***R_p= 12.0***
   f. Component Amplification Factor, ***a_p = 2.5***
   g. Short Term Spectral Response Acceleration Factor, ***S_{ds} = 12.64 % g***
   h. Long Period Spectral Response Acceleration Factor, ***S_{d1} = 9.36% g***
   i. Structural Safety Facto r ***= 4.0***

3.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type K or ASTM B88, Type L.

B. Annealed-Temper Copper Tube: ASTM B88, Type K or ASTM B88, Type L.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Cast Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

G. Wrought Copper Unions: ASME B16.22.

H. Grooved, Mechanical-Joint, Copper Tube Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil International.
   b. Star Pipe Products.

c. Victaulic Company.

2. Grooved-End Copper Fittings: ASTM B75, copper tube or ASTM B584, bronze castings.
3. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM-rubber gasket rated for minimum 230 deg F for use with ferrous housing, and steel bolts and nuts; 300 psig minimum pressure rating.

I. Copper-Tube, Pressure-Seal-Joint Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Mueller Industries, Inc.
b. NIBCO INC.
c. Viega LLC.

2. Source Limitations: Obtain copper-tube pressure-seal-joint fittings from single manufacturer.
3. Housing: Copper or bronze.
4. O-Rings and Pipe Stops: EPDM.
5. Tools: Manufacturer's special tools.
6. Minimum 250-psig working-pressure rating at 250 deg F.

3.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, and schedule number as indicated in "Part 3, Piping Applications" Article.

B. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

C. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

D. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

E. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

F. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International.

b. Grinnell G-Fire by Johnson Controls Company.
c. Victaulic Company.

2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

G. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

3.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F441/F441M, with wall thickness as indicated in "Piping Applications" Article.

B. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, Smoke and Fire Ratings:ASTM F438 for Schedule 40 pipe; ASTM F439 for Schedule 80 pipe.

C. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.

D. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.

E. Smoke and Fire Ratings:

1. Where indicated on the Drawings that a plenum-rated piping system is required, the pipe is to be wrapped and/or insulated with fiberglass or mineral wool pipe insulation, field installed.

a. The system is to have a flame spread classification of less than 25 and smoke development rating of less than 50.
b. Pipe, wrap, or insulation as a system to meet the requirements of CAN/ULC-S102.2-03, ASTM E84 or UL 2846.
c. For insulation required for thermal and condensation reasons, see Section 230719 "HVAC Piping Insulation."
d.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125 or Class 250 cast-iron and cast-bronze flanges.
b. Full face or Narrow-Face Type: For raised-face, Class 150, and Class 300 ductile-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for CPVC Piping: ASTM F493.Solvent Cements for PVC Piping: ASTM D2564. Include primer according to ASTM F656.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. WATTS.
b. Wilkins.
c. Zurn Industries, LLC.

2. Source Limitations: Obtain dielectric unions from single manufacturer.
3. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 250 psig.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.

c. GF Central Plastics .
d. GPT Industries.

2. Source Limitations: Obtain dielectric-flange insulating kits from single manufacturer.
3. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 250 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

D. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Elster Perfection; a Honeywell Corporation.
b. Grinnell G-Fire by Johnson Controls Company.
c. Matco-Norca.
d. Victaulic Company.

2. Description:

a. Standard: IAPMO PS 66.
b. Electroplated steel nipple, complying with ASTM F1545.
c. Pressure Rating: Minimum 300 psig at 225 deg F.
d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

PART 4 - EXECUTION

4.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type K or Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed or pressure-seal joints.
2. Schedule 40, Grade B steel pipe; Class 150, malleable-iron Class 250, cast-iron or Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

1. Type K, or Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Hot-water heating piping, aboveground, NPS 12 and larger, shall be any of the following:

1. Schedule standard steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

D. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type K or Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron Class 250, cast-iron Class 300, malleable-iron fittings; wrought-steel fittings and wrought-cast or forged-steel fittings and threaded joints.

E. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

1. Type K or Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, Class 150 or higher, malleable-iron fittings; wrought-steel fittings and wrought-cast or forged-steel fittings and threaded joint, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

F. Chilled-water piping, aboveground, NPS 12 and larger, shall be any of the following:

1. Schedule standard steel pipe, Class 150 or higher wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule standard steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

G. Condenser-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type K or Type L , drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron Class 250, cast-iron Class 300, malleable-iron fittings; wrought-steel fittings and wrought-cast or forged-steel fittings and threaded joints.

H. Condenser-water piping, aboveground, NPS 2-1/2 to NPS 12, shall be any of the following:

1. Type K or Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, Class 150 or higher, malleable-iron fittings; wrought-steel fittings and wrought-cast or forged-steel fittings and threaded joint, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

I. Condenser-water piping, aboveground, NPS 12 and larger, shall be any of the following:

1. Schedule standard steel pipe, Class 150 or higher wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule standard steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

J. Makeup-water piping installed aboveground : See Plumbing Piping specifications.

K. Condensate-Drain Piping, Copper: Type M or Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints

L. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

M. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K or type L, annealed-temper copper tubing with soldered or flared joints.

N. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

4.2 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install pressurized piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe. Mechanically formed tee fittings are not acceptable.

P. Install valves according to Section 230523 “General-Duty Valves for HVAC Piping.”

Q. Install air vents and safety valves in accordance with Section 232116 “Hydronic Piping Specialties.”

R. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

S. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

T. Install shutoff valve immediately upstream of each dielectric fitting.

U. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, anchors, and pipe alignment guides.

V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

4.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32. Do not use solder joints on pipe sizes greater than NPS 2

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D2855.
4. PVC Nonpressure Piping: Join according to ASTM D2855.

I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

J. Pressure-Sealed Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

4.4 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 2-1/2 and larger: Use dielectric flange kits.

4.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

C. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each elbow.

E. Support vertical runs of copper tubing and steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

G. Maximum hanger spacing and minimum rod diameters for water piping shall be as follows:

Nominal Pipe Dia	Standard Steel Pipe		Copper Tube	
NPS (inches)	Max Hanger Spacing (ft)	Min Rod Size (inches)	Max Hanger Spacing (ft)	Min Rod Size (inches)
0.50	7.00	0.38	5.00	0.38
0.75	7.00	0.38	5.00	0.38
1.00	7.00	0.38	6.00	0.38
1.50	9.00	0.38	8.00	0.38
2.00	10.00	0.38	8.00	0.38
2.50	11.00	0.50	9.00	0.50
3.00	12.00	0.50	10.00	0.50
4.00	14.00	0.68	12.00	0.50
6.00	17.00	0.75	14.00	0.68
8.00	19.00	0.75	16.00	0.75
10.00	22.00	0.88		
12.00	23.00	0.88		
14.00	25.00	1.00		
16.00	27.00	1.00		
18.00	28.00	1.00		
20.00	30.00	1.25		
24.00	32.00	1.50		
30.00	32.00	1.75		
36.00	34.00	2.00		
42.00	34.00	2.25		
48.00	34.00	2.50		

Cast iron pipe: 5 feet max hanger spacing, support at all joints, 0.38 inch rod.
PVC pipe: 6 feet max hanger spacing, 0.38” rod.
Note: Maximum point loading at structure shall be reviewed with Structural Engineer of Record and contractor’s delegated design partner.

4.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections unless otherwise specified.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gauges for HVAC Piping."

4.7 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

4.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test.
5. After hydrostatic test pressure has been applied for at least 24 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. For each test conducted, prepare written report of testing. Include date of test, name of individual conducting test, system design pressure, system test pressure at start of test and system test pressure at end of test. Include location of leaks and measure taken to correct leaks. List of items isolated / removed /not tested due to pressure limitations.

4.9 SYSTEM STARTUP

A. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523 "General Duty Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.7 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Hydronic piping shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and remain operational after a seismic event.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. *Provide Seismic restraints for piping systems that meet or exceeds site seismic requirements below;*
   a. Seismic Design Category C
   b. Seismic Risk Category IV
   c. Seismic Use Group III
   d. Component Importance Factor, ***I_p = 1.5***
   e. Component Response Modification Factor, ***R_p= 12.0***
   f. Component Amplification Factor, ***a_p = 2.5***
   g. Short Term Spectral Response Acceleration Factor, ***S_{ds} = 12.64 % g***
   h. Long Period Spectral Response Acceleration Factor, ***S_{d1} = 9.36% g***
   i. Structural Safety Factor ***= 4.0***

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Armstrong Pumps, Inc.
b. Bell & Gossett; a Xylem brand.
c. Griswold Controls.
d. Red-White Valve Corp.
e. TACO Comfort Solutions, Inc.
f. Tour and Anderson

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. Pressure Rating: Minimum 250 psig.
10. Maximum Operating Temperature: 250 deg F.

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Bell & Gossett; a Xylem brand.
b. Griswold Controls.
c. Nexus Valve, Inc.
d. Victaulic

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. Pressure Rating: Minimum 250 psig.
11. Maximum Operating Temperature: 250 deg F.

C. Iron, Compact-wafer, Center-Guided Check Valve with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo International
b. Bell & Gossett; a Xylem brand.

c. Metraflex Company (The)
d. Mueller Steam Specialty
e. Titan Flow Control, Inc.

2. Standard: MSS SP-125
3. Style: Compact wafer, spring loaded.
4. Body:Ductile iron , Carbon steel
5. Pressure Rating: Minimum 250 psig.
6. Rated for operation: 250 deg F.
7. Seat: EDPM or NBR

D. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AMTROL, Inc.
b. Apollo Flow Controls; Conbraco Industries, Inc.
c. Armstrong Pumps, Inc.
d. Bell & Gossett; a Xylem brand.
e. Spence Engineering Company, Inc.
f. WATTS.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AMTROL, Inc.
b. Apollo Flow Controls; Conbraco Industries, Inc.
c. Armstrong Pumps, Inc.
d. Bell & Gossett; a Xylem brand.
e. Spence Engineering Company, Inc.
f. WATTS.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.

4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: stainless steel , removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.2 AIR-CONTROL DEVICES

A. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. Nexus Valve, Inc.
    e. NuTech Hydronic Specialty Products.
    f. Spirotherm, Inc.
    g. TACO Comfort Solutions, Inc.
    h. Dezurik APCO

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. Pressure Rating: Minimum 250 psig.
8. Maximum Operating Temperature: 240 deg F.

B. Bladder-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. TACO Comfort Solutions, Inc.
    d. Patterson

2. Tank: Welded steel, rated for 250-psig working pressure and 250 deg F maximum operating temperature. Factory test after taps are fabricated and

supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

C. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Coalescing-Type Air and Dirt Separators:

1. Tank: Fabricated steel tank; ASME constructed and stamped for 250-psig working pressure and 250 deg F maximum operating temperature.
2. Coalescing Medium: Stainless steel.
3. Air Vent: Threaded to the top of the separator.
4. Inline Inlet and Outlet Connections: Threaded for NPS 2 and smaller; Class 150 flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded to the bottom of the separator.
6. Size: Match system flow capacity.

E. Air Purgers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett; a Xylem brand.
    d. TACO Comfort Solutions, Inc.
    e. Patterson

2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Pressure Rating: Minimum 250 psig.
4. Maximum Operating Temperature: 250 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
4. Pressure Rating: Minimum 250 psig

B. Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. Pressure Rating: Minimum 250 psig

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. Pressure Rating: Minimum 250 psig
5. Maximum Operating Temperature: 250 deg F.

2.5 GROOVED CONNECTION SPECIALTIES

A. Alternate: Contractor may substitute isolation/check/strainers from the following vendors in lieu of the components within this section provided the materials, pressure ratings are of equal or greater quality than what is specified.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Victaulic.
b. Anvil Corporation.

2.6 GROOVED CONNECTION MODULAR EQUIPMENT CONNECTION ASSEMBLIES

A. All components listed below shall meet the requirements listed elsewhere in this specification.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Victaulic.
b. Anvil Corporation.

B. Pump Trim: Suction
1. Series 382 Strainer Vibration Isolation Pump Drop. Factory assembled grooved end vibration suction drop for pipe sizes 3” through 12”. Orange enamel coated

assembly, consisting of a 90-degree base elbow with Class 150 Flange for pump connection, Wye pattern strainer with stainless steel perforated metal basket, butterfly vale with offset stem for 360-degree circumferential seating, and pipe spool(s) with thermometer and/or pressure ports. Assembly is installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure to 300-psig. Standard Acceptance: Victaulic Series 382

C. Pump Trim: Discharge
   1. Series 380 Discharge Vibration Pump Drop. Factory assembled grooved end vibration pump discharge drop for pipe sizes 3” through 12” Orange enamel coated assembly, consisting of a Class 150 flange for pump connection, [base elbow for horizontal pump connection] [straight line with concentric reducer for vertical pump connections], tri-service valve assembly consisting of a spring-actuated check valve and butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and pressure ports. Assembly is installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure to 300-psig Standard of Acceptance: Victaulic Series 380.

D. Header
   1. Factory-fabricated grooved end header all-in-one assembly for fluid distribution. Header shall consist of an ASTM A53, Grade B, standard weight pipe spool with required outlet connections. Grooved ends roll grooved to Victaulic OGS dimensions, with enamel coating or galvanized to project requirements. Standard of Acceptance: Victaulic Vic-Header.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install throttling-duty calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal and each chiller evaporator and chiller condenser

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

G. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

H. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

I. If valves with specified SWP classes or pressure ratings are unavailable, the same types of valves with higher SWP classes or pressure ratings may be substituted.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

F. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

G. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Close-coupled, end-suction centrifugal pumps.
3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
4. Separately coupled, vertically mounted, in-line centrifugal pumps.
5. Separately coupled, base-mounted, end-suction centrifugal pumps.
6. Separately coupled, base-mounted, double-suction centrifugal pumps.
7. Separately coupled, vertically mounted, double-suction centrifugal pumps.
8. Separately coupled, vertically mounted, turbine centrifugal pumps.
9. Wet-rotor pumps.
10. Automatic condensate pump units.

1.3 DEFINITIONS

A. ECM: Electronically commutated motor.

B. EPDM: Ethylene propylene diene monomer.

C. EPR: Ethylene propylene rubber.

D. FKM: Fluoroelastomer polymer.

E. HI: Hydraulic Institute.

F. NBR: Nitrile rubber or Buna-N.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of pump.

1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
2. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each pump.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for pumps, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Seismic Performance: Hydronic pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

3. Provide Seismic restraints for pump systems that meet or exceeds site seismic requirements below;
a. Seismic Design Category C
b. Seismic Risk Category IV
c. Seismic Use Group III
*d. Component Importance Factor, **I_p = 1.5***
*e. Component Response Modification Factor, **R_p= 1.0***
*f. Component Amplification Factor, **a_p = 2.5***
*g. Short Term Spectral Response Acceleration Factor, **S_{ds} = 12.64 % g***
*h. Long Period Spectral Response Acceleration Factor, **S_{d1} = 9.36% g***
*i. Structural Safety Factor **= 4.0***

3.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. American-Marsh Pumps.
2. Armstrong Pumps, Inc.
3. Flowserve Corporation.
4. Grundfos Pumps Corporation.
5. ITT Corporation.
6. Mepco, LLC.

7. PACO Pumps; Grundfos Pumps Corporation, USA.
8. Peerless Pump Company.
9. TACO Comfort Solutions, Inc.
10. Patterson Pump

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

D. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange or union-end connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Type 304 stainless steel.
4. Pump Stub Shaft: Type 304 or Type 316 stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.

E. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.

F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure : Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Single or Variable-speed motor per application.
6. Provide integral pump motor variable-speed controller were indicated

G. Capacities and Characteristics:

1. See drawing schedules

3.3 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Armstrong Pumps, Inc.
2. Flowserve Corporation.
3. Grundfos Pumps Corporation.
4. ITT Corporation.
5. PACO Pumps; Grundfos Pumps Corporation, USA.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.
8. Patterson Pump

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

D. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gauge tappings at inlet and outlet, and threaded companion-flange or flanged connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Bronze.
4. Pump Stub Shaft: Type 304 or Type 316 stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR bellows and gasket. Include water slinger on shaft between motor and seal.

E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Single or Variable-speed motor per application.
6. Provide integral pump motor variable-speed controller where indicated.

F. Capacities and Characteristics:

1. See drawing schedules .

3.4 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Armstrong Pumps, Inc.
2. Flowserve Corporation.
3. ITT Corporation.
4. PACO Pumps; Grundfos Pumps Corporation, USA.
5. TACO Comfort Solutions, Inc.
6. Patterson Pump

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

D. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, and threaded companion-flange or union-end connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Type 304 stainless steel or Type 316 stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR bellows and gasket.
5. Pump Bearings: Permanently lubricated ball bearings.

E. Shaft Coupling: Molded-rubber insert with interlocking spider capable of absorbing vibration.

F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Single or Variable-speed motor per application
6. Provide integral pump motor variable-speed controller where indicated.

G. Capacities and Characteristics:

1. Capacity: See drawing schedules .

3.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Armstrong Pumps, Inc.
2. Flowserve Corporation.
3. ITT Corporation.
4. Mepco, LLC.
5. PACO Pumps; Grundfos Pumps Corporation, USA.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.
8. Patterson Pump

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

D. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Type 304 stainless steel or Type 316 stainless steel.
4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR bellows and gasket.
5. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor EPDM coupling sleeve for variable-speed applications.

F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

H. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Single or Variable-speed motor per application.
6. Provide integral pump motor variable-speed controller where indicated.

I. Capacities and Characteristics:

1. Capacity: See drawing schedules..

3.6 SEPARATELY COUPLED, BASE-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Armstrong Pumps, Inc.
2. Flowserve Corporation.
3. Grundfos Pumps Corporation.
4. ITT Corporation.
5. PACO Pumps; Grundfos Pumps Corporation, USA.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.
8. Patterson Pump

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

D. Pump Construction:

1. Casing: Horizontally split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, Class 150 ~~Class 250~~ flanges. Casing supports shall allow removal and replacement of impeller without disconnecting piping.

2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Type 304 or Type 316 stainless steel.
4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR bellows and gasket.
5. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR bellows and gasket.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.

F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

H. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Single or Variable-speed motor per application
6. Provide integral pump motor variable-speed controller where indicated

I. Capacities and Characteristics:

1. Capacity: See drawing Schedules.

3.7 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast ductile-iron body and end cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and Type 304 stainless steel permanent strainers with 3/16-inch.

4. Type 304 stainless steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig pressure rating, cast ductile-iron body, pump-discharge fitting.
3. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
4. Brass valve disc with EPDM rubber seat.
5. Type 304 stainless steel valve stem.
6. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
7. Brass gauge ports with integral check valve and orifice for flow measurement.

PART 4 - EXECUTION

4.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

4.2 PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers of size required to support weight of in-line pumps.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

4.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.

C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

D. Comply with pump and coupling manufacturers' written instructions.

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

4.4 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check, shutoff, and throttling valves or check valve and throttling valve with memory stop or triple-duty valve on discharge side of pumps.

F. Install Y-type strainer or suction diffuser and shutoff valve on suction side of pumps.

1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

4.5 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

4.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

4.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

4.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Hydronic pumps will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

4.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 232213 - STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Steel pipe and fittings.
   2. Joining materials.

B. Related Requirements:
   1. Section 230529 “Hangers and Supports for HVAC Piping and Equipment” for installation of piping.
   2. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Steel pipe and fittings.
   2. Joining materials.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to the following:
1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
1. HP Steam Piping: 150 psig at 366 deg F
2. Condensate Piping: 150 PSIG at 366 deg F.
3. Makeup-Water Piping: 150 psig at 150 deg F.
4. Blowdown-Drain Piping: 150 psig at 366 deg F.
5. Air-Vent and Vacuum-Breaker Piping: 150 psig at 366 deg F.
6. Safety-Valve-Inlet and -Outlet Piping: 150 psig at 366 deg F.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A120, black steel, plain ends, seamless, Grade B.

B. Cast-Iron Threaded Fittings: ASME B16.4; Class 300.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Class 300.

D. Malleable-Iron Unions: ASME B16.39; Class 300.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 ; raised ground face, and bolt holes spot faced. For use only on boiler feedwater < 200 deg F.

F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face flanges.
      b. Narrow-Face Type: For raised-face flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel of type to match pipe unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 - EXECUTION

3.1 HP STEAM PIPING APPLICATIONS

A. HP Steam Piping, NPS 2 and Smaller:
   1. Schedule 80, Type S, Grade B, steel pipe; Class 250 cast-iron fittings; and threaded joints.

B. HP Steam Piping, NPS 2-1/2 through NPS 12:
   1. Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and smaller:
   1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Boiler feedwater piping above grade, NPS 2 and smaller:
1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Boiler feedwater piping above grade, NPS 2-1/2 and larger:
1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

G. Boiler blowdown piping above grade, NPS 2 and smaller:
1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

H. Boiler blowdown piping above grade, NPS 2-1/2 and larger:
1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 ANCILLARY PIPING APPLICATIONS

A. Vacuum-Breaker Piping: Outlet, same as service where installed.

B. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to the following Sections or other Sections as needed:
   1. Section 230523.11 "Globe Valves for HVAC Piping."
   2. Section 230523.12 "Ball Valves for HVAC Piping."
   3. Section 230523.13 "Butterfly Valves for HVAC Piping."
   4. Section 230523.14 "Check Valves for HVAC Piping."
   5. Section 230523.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

U. Install three valve bypass assemblies around control valves.

   1. Isolation valves are to be gate valves or ball valves of same size as piping.

a. If reducers are on either side of control valve, isolation valves are to be same size as the larger of the piping around each reducer.

2. Bypass valve shall be of same valve configuration type, connection type and size as the control valve.

V. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

W. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

X. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

Y. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 INSTALLATION OF STEAM AND CONDENSATE PIPING SPECIALTIES

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic restraints in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers, supports, and anchor devices.

C. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.

2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply piping and steel steam condensate piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support horizontal piping within 12 inches of each fitting.

G. Support vertical runs of steel steam supply piping and steel steam condensate piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

H. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush system with clean water. Clean strainers.
   4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
   3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening,

repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports.

END OF SECTION 232213

SECTION 232216 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Strainers.
2. Flash tanks.
3. Stop-check valves.
4. Steam safety valves.
5. Pressure-reducing valves.
6. Steam traps.
7. Thermostatic air vents and vacuum breakers.
8. Flexible connectors.

B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523 "General duty Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.
3. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Flash tank.
3. Valve.
4. Steam trap.
5. Air vent and vacuum breaker.
6. Connector.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: 125 psig
2. Condensate Piping: 100 psig at 250 deg F.
3. Makeup-Water Piping: 150 psig at 150 deg F
4. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

A. Y-Pattern Strainers, Cast Iron:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Keckley Company.
c. Metraflex Company (The).
d. Mueller Steam Specialty; A Watts Water Technologies Company.

2. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
4. Strainer Screen: Stainless steel, 60 mesh strainer or perforated stainless-steel basket.
5. Tapped blowoff plug.
6. Rating: 250-psig working steam pressure.

2.3 FLASH TANKS

A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code for 150-psig rating, and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.4 STOP-CHECK VALVES

A. Stop-Check Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. A.Y. McDonald Mfg. Co.
    b. Crane Fluid Systems; Crane Co.
    c. Jenkins Valves.

2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.5 STEAM SAFETY VALVES

A. Bronze orBrassSteam Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Armstrong International, Inc.

b. Kunkle Valve.
c. Spirax Sarco Limited.
d. WATTS; A Watts Water Technologies Company.

2. Disc Material: Forged copper alloy.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Steam Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Armstrong International, Inc.
b. Kunkle Valve.
c. Spirax Sarco Limited.
d. WATTS; A Watts Water Technologies Company.

2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.6 PRESSURE-REDUCING VALVES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Armstrong International, Inc.
2. Leslie Controls, Inc.
3. Spence Engineering Company, Inc.

4. Spirax Sarco Limited.

B. ASME labeled.

C. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

D. Description: Pilot-actuated diaphragm type, with adjustable pressure range and positive shutoff.

E. Body: Cast iron.

F. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.

G. Trim: Hardened stainless steel.

H. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

I. Gaskets: Non-asbestos materials.

2.7 STEAM TRAPS

A. Thermostatic Steam Traps, Bronze:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Armstrong International, Inc.
    b. Hoffman Specialty; Bell & Gossett, a xylem brand.
    c. Spirax Sarco Limited.

2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.

B. Float and Thermostatic Steam Traps, Cast Iron:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Armstrong International, Inc.

b. Hoffman Specialty; Bell & Gossett, a xylem brand.
c. Spirax Sarco Limited.

2. Body and Bolted Cap: ASTM A126 cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig (860 kPa).

C. Inverted Bucket Steam Traps, Cast Iron:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Armstrong International, Inc.
b. Hoffman Specialty; Bell & Gossett, a xylem brand.
c. Spirax Sarco Limited.

2. Body and Cap: Cast iron.
3. End Connections: Threaded.
4. Head and Seat: Stainless steel.
5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
6. Bucket: Brass or stainless steel.
7. Strainer: Integral stainless steel inlet strainer within the trap body.
8. Air Vent: Stainless steel thermostatic vent.
9. Pressure Rating: 250 psig (1725 kPa).

2.8 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Armstrong International, Inc.
b. Hoffman Specialty; Bell & Gossett, a xylem brand.
c. Spirax Sarco Limited.

2. Body: Cast iron, bronze, or stainless steel.

3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless steel cage.
6. Pressure Rating: 125 psig
7. Maximum Temperature Rating: **375 deg F**

B. Vacuum Breakers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: Ethylene propylene rubber.
6. Pressure Rating: [**125 psig (861 kPa)**] [**300 psig (2068 kPa)**] <**Insert value**>.
7. Maximum Temperature Rating: [**350 deg F (177 deg C)**] <**Insert temperature**>.

2.9 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Hyspan Precision Products, Inc.
   b. Metraflex Company (The).

2. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inch (20-mm) misalignment.
5. CWP Rating: 150 psig (1035 kPa).
6. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without

valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 INSTALLATION OF PIPING

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 full-port ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install valves according to Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," Section 230523.14 "Check Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Flash Tank:

1. Pitch condensate piping down toward flash tank.
2. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
3. Install thermostatic air vent at tank top.
4. Install safety valve at tank top.
5. Install full-port ball valve, and swing check valve on condensate outlet.
6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for 3 times the calculated heat load.
7. Install pressure gage on low-pressure steam outlet according to Section 230519 "Meters and Gages for HVAC Piping."

3.3 INSTALLATION OF STEAM TRAPS

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 INSTALLATION OF PRESSURE-REDUCING VALVES

A. Install pressure-reducing valves in accessible location for maintenance and inspection.

B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.

C. Install gate valves on both sides of pressure-reducing valves.

D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.

E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Section 230519 "Meters and Gages for HVAC Piping."

F. Install strainers upstream for pressure-reducing valve.

G. Install safety valve downstream from pressure-reducing valve station.

3.5 INSTALLATION OF SAFETY VALVES

A. Install safety valves according to ASME B31.1, "Power Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION 232216

SECTION 232223 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-stage, centrifugal pumps with floor-mounted receiver.
2. Two-stage, centrifugal pumps with floor-mounted receiver.
3. Single-stage, centrifugal pumps with elevated receiver.
4. Vertical, wet-pit-mounted duplex pumps.
5. Pressure-powered pumps.

1.2 DEFINITIONS

A. PPE: Polyphenylene ether.

B. PPO: Polyphenylene oxide.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of steam condensate pump.

1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories.
2. Indicate pump's operating point on curves.
3. Include receiver capacity and material.

B. Shop Drawings: For each pump/receiver.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates for steam condensate pumps/receivers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1. Indicate actual installed items by marking submittals with an arrow or box.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of pump from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

D. Seismic Performance: Steam condensate pumps/receivers to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. **Component Amplification Factor: 1.5**
4. **Component Response Modification Factor**. 1.0

2.3 SINGLE-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Armstrong International, Inc.
2. ITT Corporation.
3. Skidmore Pump.
4. Sterling.

B. Description: Factory-fabricated, packaged, duplex, electric-driven pumps; with receiver, float switch(es), controls, and accessories suitable for operation with steam condensate up to 200 deg F (93 deg C).

C. Receiver:

1. Floor mounted.
2. Material: [**Cast iron**] [**Carbon steel**] [**Stainless steel**].
3. Externally adjustable float switches.
4. Flanges for pump mounting.
5. Water-level gauge and dial thermometer.
6. Pressure gauge at each pump discharge.
7. Isolation valve between pump and receiver.
8. Lifting eyebolts.
9. Vent and overflow.
10. Inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.

D. Pumps:

1. Centrifugal, close coupled, vertical design.
2. Permanently aligned.
3. Impeller: Bronze.
4. Mechanical seals rated at 250 deg F (120 deg C).
5. Mounted on receiver flange.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Open, dripproof.
3. Enclosure Materials: Cast iron, cast aluminum, or rolled steel.
4. Motor Bearings: Permanently lubricated ball bearings.
5. Service Conditions:

    a. Ambient Temperature: 100 F
    b. Altitude: 700 feet above sea level.

6. Efficiency: Premium efficient.
7. Service Factor: 1.15

F. Control Panel:

1. NEMA 250, Type 12 enclosure with hinged door and grounding lug, mounted on pump.

2. Combination magnetic starter with fused disconnect for each pump, and cover interlock.
3. Factory wired between pumps and float switches, for single external electrical connection.
4. Provide fused, control-power transformer if exceeds 230 V ac.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual control to override electrical pump alternator and manually select the lead pump.
7. Hand-off-auto selector switch.
8. Momentary-contact "TEST" push button on cover for each pump.
9. Numbered terminal strip.
10. Disconnect switch.

G. Capacities and Characteristics:

1. Number of Pumps: 2
2. Capacity, Each Pump:

    a. Flow: <**Insert gpm (L/s)**>.
    b. Discharge Head: <**Insert psig (kPa)**>.
    c. Discharge Size: <**Insert NPS (DN)**>.
    d. Speed: <**Insert rpm**>.
    e. Motor Horsepower: <**Insert value**>.

3. Receiver:

    a. Capacity: <**Insert gal. (L)**>.
    b. Inlet Size: <**Insert NPS (DN)**>.
    c. Height to Inlet: <**Insert inches (mm)**>.

4. Electrical Characteristics:

    a. Volts: [**120**] [**230**] [**240**] <**Insert value**>.
    b. Phase: Single.
    c. Hertz: 60.
    d. Full-Load Amperes: <**Insert value**> A.
    e. Minimum Circuit Ampacity: <**Insert value**> A.
    f. Maximum Overcurrent Protection: <**Insert value**> A.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

B. Support pumps and piping separately so piping is not supported by pumps.

C. Install thermometers and pressure gauges.

D. Equipment Mounting:

1. Install pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Piping" and Section 232216 "Steam and Condensate Piping Specialties."

B. Where installing piping adjacent to machine, allow space for service and maintenance.

C. Install a globe and check valve at inlet of each pump and a gate and check valve at pump outlet.

D. Install pressure gauge at each pump discharge.

E. Pipe drain to nearest floor drain for overflow and drain piping connections.

F. Install full-size vent piping to outdoors, terminating in 180-degree elbow.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 SYSTEM STARTUP

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Clean strainers.
3. Adjust steam condensate pump controls.
4. Adjust pump controls for automatic start, stop, and alarm operation.
5. Perform the following operational checks before starting:

    a. Set float switches to operate at proper levels.
    b. Check motors for proper rotation.
    c. Test pump controls and demonstrate compliance with requirements.
    d. Replace damaged or malfunctioning pump controls and equipment.
    e. Verify that pump controls are correct for required application.

6. Start steam condensate pumps in accordance with manufacturer's written startup instructions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps.

END OF SECTION 232223

SECTION 232300 - REFRIGERANT PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Comply with ASHRAE 15.

B. Comply with ASME B31.5.

C. Test refrigerant piping at 1.5 times maximum working pressure of refrigerant line for service application.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   1. Thermostatic expansion valves.
   2. Solenoid valves.
   3. Hot-gas bypass valves.
   4. Filter dryers.
   5. Strainers.
   6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
   1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and

pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Refrigerant Piping Hydronic shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

3. *Provide Seismic restraints for pump systems that meet or exceeds site seismic requirements below;*
   a. *Seismic Design Category C*
   b. *Seismic Risk Category IV*
   c. *Seismic Use Group III*
   d. *Component Importance Factor,* $I_p = 1.5$
   e. *Component Response Modification Factor,* $R_p = 1.0$
   f. *Component Amplification Factor,* $a_p = 2.5$
   g. *Short Term Spectral Response Acceleration Factor,* $S_{ds} = 12.64\ \%\ g$
   h. *Long Period Spectral Response Acceleration Factor,* $S_{d1} = 9.36\%\ g$
   i. *Structural Safety Factor* **= 4.0**

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
   4. Pressure and Temperature ratings: Minimum of 1.5 times maximum operating pressure at operating temperature. All components must be specifically designed for use with refrigerant and for specific use and application.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Pressure and Temperature ratings: Minimum of 1.5 times maximum operating pressure at operating temperature. All components must be specifically designed for use with refrigerant and for specific use and application.

F. Flanged Unions:
1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.

G. Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
2. End Connections:
   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.

2.4 VALVES AND SPECIALTIES

A. Pressure and Temperature ratings: Minimum of 1.5 times maximum operating pressure at operating temperature. All components must be specifically designed for use with refrigerant and for specific use and application.

B. Diaphragm Packless Valves:
1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.

C. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.

3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.

D. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.

E. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.

F. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and ac coil.
6. Manual operator.

G. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.

H. Thermostatic Expansion Valves: Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F .
6. Superheat: Adjustable .
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.

I. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.

2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and ac coil.
8. End Connections: Socket.
9. Set Pressure: As required.
10. Throttling Range: Maximum 5 psig.

J. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.

K. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.

L. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.

M. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.

N. Permanent Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. End Connections: Socket.
4. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.

O. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.

P. Receivers: Comply with ARI 495.
1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.

Q. Liquid Accumulators: Comply with ARI 495.
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.

2.5 REFRIGERANTS

R. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work for specific use include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

C. ASHRAE 34, R-513A: R134a/R123yf blend.- Heat Recovery Chillers

D. ASHRAE 34, R1233zd - Non Heat Recovery Chillers

E. ASHRAE 34, R410A- Packaged Computer Room Air Conditioners

PART 3 EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANTS

F. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type ACR L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 4: Copper, Type ACR K L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

D. Safety-Relief-Valve Discharge Piping:

1. 3” NPS and below-Copper, Type ACR, K, or L, drawn-temper tubing and wrought-copper fittings with soldered joints.
2. 3 1/2” NPS and above, Schedule 40, black-steel and wrought-steel fittings with welded, flanged or threaded joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
   3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
   6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

F. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
   2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
   3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
   4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
   9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
   2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
   3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
   4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
   1. Comply with ASME B31.5, Chapter VI.
   2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
   3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
      a. Fill system with nitrogen to the required test pressure.
      b. System shall maintain test pressure at the manifold gage throughout duration of test.
      c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
      d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.

3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following HVAC water-treatment systems:

1. Manual and automatic chemical-feed equipment and controls.
2. Stainless steel pipes and fittings.
3. CPVC Bleach Piping
4. Teflon lined CS Acid Piping
5. CPVC Acid Piping
6. Chemical-treatment test equipment.
7. Chemicals.
8. TDS controllers.
9. TSS controllers.

1.3 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

B. PPM: Parts per million.

C. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.

D. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
1. Bypass feeders
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.

5. TDS controllers.
6. TSS controllers.
7. Biocide feeder timers.
8. Chemical solution tanks.
9. Injection pumps.
10. Chemical test equipment.
11. Chemical material safety data sheets.

B. Shop Drawings: Pretreatment equipment and chemical- treatment equipment, showing tanks, maintenance space required, and piping connections to HVAC systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For chemical-treatment equipment and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

C. Field quality-control reports.

D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

E. Water Analysis: Illustrate water quality available at Project site.

F. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 HVAC WATER-TREATMENT MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Weas Engineering; Local Rep: Kyle Powell Phone: 317-767-9937 E-mail: Kyle.Powell@weasengineering.com

2.2 PERFORMANCE REQUIREMENTS

A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems as indicated in this Specification. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
1. Chilled Water Total Volume: 39,400 Gallons
2. Heating Hot Water Volume: 25,800 Gallons
3. Steam and Steam Condensate system: 48,300 lbs/hr

C. Closed hydronic systems, including hot-water heating below 250 deg F and chilled water shall have the following water qualities:

1. pH: Maintain a value within 9.0 – 10.0
2. Alkalinity: Maintain a value within 100-400 mg/L as CaCO(3).
3. Steel Corrosion Inhibiters: Provide sufficient inhibitors to limit mild steel corrosion to <0.3 mils per year. Maintain soluble iron concentrations at or below <0.5 mg/L.
4. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to <0.10 mils per year. Maintain soluble copper concentrations at or below <0.25 mg/L.
5. Scale Control: Provide softened water for initial fill and makeup. Where softened water is not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.
6. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
7. Chemical Oxygen Demand: Maintain maximum value of 100 ppm.

8. Microbiological Limits:
    a. Total Aerobic Plate Count: Maintain a maximum value of 1,000 organisms (cells)/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of <50 organisms (cells)/mL.
    c. Nitrate Reducers: Maintain a maximum value of <50 organisms (cells) /mL.
    d. Sulfate Reducers: Maintain a maximum value of 0, or not detectable, organisms (cells) /mL.
    e. Iron Bacteria: Maintain a maximum value of 0, or not detectable, organisms (cells) /mL.

D. Open hydronic systems, including condenser water, shall have the following water qualities:

1. pH: Maintain a value within 8.0 – 9.0.
2. Alkalinity: Maintain a maximum value of <100 mg/L as CaCO(3).
3. Silica in Cooling Towers: Maintain a value no higher than 100 mg/L.
4. Silica in Evaporative Condensers: Maintain a value no higher than 100 mg/L.
5. Hardness in Cooling Towers: Maintain a value no higher than 400 mg/L as CaCO(3).
6. Hardness in Evaporative Condensers: Maintain a value no higher than 400 mg/L as CaCO(3).
7. Steel Corrosion Inhibiters: Provide sufficient inhibitors to limit mild steel corrosion to <3 mils per year. Maintain soluble iron concentrations at or below 1 mg/L.
8. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to <0.3 mils per year. Maintain soluble copper concentrations at or below <0.3 mg/L.
9. Scale Control: Provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.
10. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
11. Microbiological Limits:
    a. Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms (cells) /mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of <1,000 organisms (cells) /mL.
    c. Nitrate Reducers: Maintain a maximum value of <50 organisms (cells) /mL.
    d. Sulfate Reducers: Maintain a maximum value of <50 organisms (cells) /mL.
    e. Iron Bacteria: Maintain a maximum value of <50 organisms (cells) /mL.

E. Passivation for Galvanized Steel:

1. Passivation of all galvanized-steel cooling towers and other system components must be conducted strictly in accordance with manufacturer's instructions in order to validate warranties. During the required passivation period, all water-quality parameters must be maintained in accordance with manufacturer's specifications, and all other requirements must be observed.

2. Water treatment vendor shall present written passivation plan to cooling tower manufacturer's representative for review, comment and approval prior to submitting plan to engineers. Submittal shall include written approval of passivation plan by cooling tower manufacturer.

F. Steam Boiler and Steam Condensate:

1. Steam Condensate:

a. pH: Maintain a value within 10.5-12
b. Alkalinity: Maintain a value no higher than 140-700 mg/L as CaCO(3).
c. Steel Corrosion Inhibiters: Provide sufficient inhibitors to limit mild steel corrosion to <3 mils per year. Maintain soluble iron concentrations at or below 1 mg/L.
d. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to 0.3 mils per year. Maintain soluble copper concentrations at or below 0.3 mg/L.
e. Ammonia: Maintain a value of 10 mg/L.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Provide quarter- turn or threaded fill cap with gasket seal and diaphragm arranged to lock the top onto the feeder when exposed to system pressure in the vessel. Provide a NPS 3/4 IN quarter-turn valve on inlet and outlet.

1. Capacity: 5 gal.
2. Minimum Working Pressure: 125 psig.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter, Turbine Type, Threaded:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded.
7. Provide an electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet.

B. Water Meter, Turbine Type, Flanged:

1. AWWA C701, turbine-type, totalization meter.

2. Body: Bronze
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Flanged.
7. Provide and electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet.

C. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Programmable timers with infinite adjustment over full range, mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

D. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

E. TDS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.

5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:
    a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
    b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

F. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from 0.001 mg/L to 50 g/L. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 4X enclosure. Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High- or low-value-alarm-light trip points, field adjustable; with silence switch.
5. Hand-off-auto switch for solenoid bleed-off valve.
6. Bleed-off valve activated indication.
7. Internal adjustable hysteresis or deadband.

G. Biocide Feeder Timer:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation, as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup, so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.
9. Biocide A and Biocide B pump running indication.

H. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump. Pump mount not needed for exterior acid and bleach tanks.
3. Capacity: see schedule for tank capacities.
4. Provide leak detector for interstitial space for chemical tanks. The leak detector to have visual alarm light and provide alarm signal to BAS.

I. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Thermoplastic construction.
4. Built-in relief valve.
5. Cord and Plug: Provide unit with 6 foot cord and plug for connection to electric wiring system including grounding connector.
6. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
7. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
8. With Accessories: Foot Valve (except for bleach and acid)

J. Chemical Solution Tubing: FEP (fluorinated ethylene propylene) tubing. Tubing to run continuous from pump to injection location .

K. Injection Assembly:

1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Two-piece stainless steel, as described in "Stainless Steel Pipes and Fittings" Article; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Check Valve: Integrated spring loaded ball check valve
5. Solution Tube Material: CPVC for bleach, 316 SS all other chemicals.
6. Assembly Pressure/Temperature Rating: Minimum 150 psig at 200 deg F.

2.5 STAINLESS STEEL PIPES AND FITTINGS

A. Stainless Steel Tubing: Comply with ASTM A269/A269M, 316L Stainless steel, Sch.10 butt welded non-polished ASTM A-312-82, ANSI B36.19-76

B. Stainless Steel Fittings: Comply with ASTM A815/A815M, Type 316, Grade WP-S.

C. Two-Piece, Full-Port, Stainless Steel Ball Valves: ASTM A351/A351M, Type 316 stainless steel body; ASTM A276/A276M, Type 316 stainless steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig steam working pressure and 600-psig cold working pressure ratings.

D. Gaskets to be 1/8” virgin Teflon

2.6 CPVC BLEACH PIPING

A. Piping and fittings: Sch.40 CPVC, ASME D-1784 Class 23447-B, solvent cement joints.

B. Gaskets to be 1/8” virgin Teflon

C. CPVC Ball valves: Class 150, Socket or Threaded ends, 3-piece union CPVC Body, with Vented CPVC ball for Sodium Hypochlorite Service, Viton seals like Hayward True Union Ball Valve

D. Strainers: CPVC Body, 150 PSIG at 70° F, Flanged Connection, Viton® Seals, 1/32-inch Perforation CPVC strainer. Hayward Plastic Y Strainer

E. Flexible tank Connector: PE with Bleach additive, Flanged, like Snyder Flexmaster Connector

F. Valve and flange safety Shields: Standard Teflon with pH indicating patch, like Ramco Safety Shields (c/o Corrosion Fluid Products Corp.)

2.7 TEFLON LINED CARBON STEEL ACID PIPING

A. Pipe and Fittings: PTFE Lined carbon steel, Sch.40, ASTM F1545,
1. Liner – PTFE ASTM D4894, D4895
2. Pipe – Schedule 40 Carbon Steel, ASTM A587 ERW

B. Joints: Welded and lap joint

C. Gaskets to be 1/8” virgin Teflon

D. Strainers: Teflon (PFA) Lined Ductlile Iron Flanged Connection, 1/32 inch Teflon strainer, like Atomac ASF Strainer

E. Static Mixer: Teflon (PFA) Lined Schedule 40 Carbon Steel Flanged Connections, with 4 fixed solid Teflon (PFA) mixing elements. Like Koflo Corporation or Equivalent.

F. Ball Valves: 150# Teflon (PFA) Lined, Ductile Iron Body, full port, flanged, Teflon lined Ductile Iron ball, Teflon lined stem, with Teflon seats and seals, like Atomac AKH2 full port ball valve

G. Flexible Tank Connector: PE with Sulfuric Acid additive, Flanged like Snyder Flexmaster Connector.

H. Valve and Flange Safety Shield: Standard Teflon with pH indicating patch like Ramco Safety Shields (c/o Corrosion Fluid Products Corp.)

I. Check Valves: 150# Teflon (PFA) Lined, Ductile Iron Body, flanged, Solid Teflon ball, with Teflon seats and seals, like Atomac ARV2 Ball Check valve.

2.8 CPVC ACID PIPING

A. Piping and fittings: Sch.40 CPVC, ASME D-1784 Class 23447-B, solvent cement joints.

B. Gaskets to be 1/8” Viton

C. CPVC Ball valves: Class 150, Socket or Threaded ends, 3-piece union CPVC Body, with CPVC, Viton seals, like Hayward True Union Ball Valve

D. Strainers: CPVC Body, 150 PSIG at 70° F, Flanged Connection, Viton® Seals, 1/32-inch Perforation CPVC strainer. Like Hayward Plastic Y Strainer

E. Flexible tank Connector: PE with Bleach additive, Flanged, like Snyder Flexmaster Connector

F. Valve and flange safety Shields: Standard Teflon with pH indicating patch, like Ramco Safety Shields (c/o Corrosion Fluid Products Corp.)

2.9 PVDF (Red Kynar) ACID PIPING

A. Piping and fittings: Schedule 80 PVDF, acid resistant Red Kynar, ASME D-3222, type 1, socket fusion joints.

B. Gaskets to be 1/8” Viton

C. PVDF Ball valves: Class 150, Socket or Threaded ends, 3-piece union Red Kynar PVDF Body, with FKM seals, like Chemtrol Tru-bloc Ball Valve

D. Valve and flange safety Shields: Standard Teflon with pH indicating patch, like Ramco Safety Shields (c/o Corrosion Fluid Products Corp.)

2.10 FEP (Fluorinated Ethylene Propylene)TUBING

A. Except as noted on the Chemical Treatment P&ID, Chemical piping to be FEP tubing inside 1-1/2” PVC conduits.

B. FEP to be clear. Wall thickness of tubing to be as required for 150 psig pressure rating. Tubing sizes as noted on drawings are OD.

C. FEP tubing to be continuous from pump to injection port with no splicing or joints.

D. Conduit pipe to be type EPC-40 PVC electrical UL651 conduit
   1. Conduit pipe to have long radius sweep elbows to match conduit piping.
   2. Solvents and Adhesives: as recommended by conduit manufacturer.

2.11 CHEMICAL-TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, TSS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers; and oxidizing biocide test for open cooling systems.

B. Sample Cooler (for steam boilers):

1. Tube: Sample.

a. Size: NPS 1/4 tubing.
b. Material: ASTM A666, Type 316 stainless steel.
c. Pressure Rating: Minimum 2000 psig
d. Temperature Rating: Minimum 850 deg F.

2. Shell: Cooling water.

a. Material: ASTM A666, Type 304 stainless steel.
b. Pressure Rating: Minimum 250 psig .
c. Temperature Rating: Minimum 450 deg F.

3. Capacities and Characteristics:

a. Tube: Sample.

1) Flow Rate: 0.25 gpm .
2) Entering Temperature: 353 deg F.
3) Leaving Temperature: 88 deg F.
4) Pressure Loss: 6.5 psig.

b. Shell: Cooling water.

1) Flow Rate: 3 gpm
2) Entering Temperature: 70 deg F.
3) Pressure Loss: 1.0 psig.

C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. Two-station rack for closed-loop systems.
2. Four-station rack for open-loop systems.

2.12 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

B. Chemicals for direct steam injection humidification and for steam used in direct contact with food to be FDA approved and safe for these uses.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drains.

B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install water-testing equipment on wall near water-chemical-application equipment.

D. Install interconnecting control wiring for chemical-treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, chilled water, and equip with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

G. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:

1. Install water meter in makeup-water supply.
2. Install inhibitor injection pumps and solution tanks with injection-timer-sensing contacts in water meter.

a. Pumps shall operate for timed interval when contacts close at water meter in makeup-water supply connection.

3. Install test equipment and furnish test-kit to Owner.
4. Install TDS controller with sensor and bleed valves.
   a. Bleed valves to cycle, to maintain maximum TDS concentration.
5. Install TSS controller with sensor and bleed valves.
   a. Bleed valves to cycle, to maintain maximum TSS concentration.
6. Install inhibitor injection timer with injection pumps and solution tanks.
   a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into main steam supply header.

H. Install automatic chemical-feed equipment for open condenser water and include the following:

1. Install water meter in makeup-water supply.
2. Install inhibitor injection pumps and solution tanks with injection-timer-sensing contacts in water meter.
   a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection.
   b. One pump is supplied for all systems (Tower, heating hot water, chilled water.)
   c. Automatic ball valves shall be provided to only send chemicals to one system at a time.
3. Install test equipment, and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install TDS controller with sensor and bleed valves.
   a. Bleed valves to cycle, to maintain maximum TDS concentration.
5. Install TSS controller with sensor and bleed valves.
   a. Bleed valves to cycle, to maintain maximum TSS concentration.
6. Install pH sensor and controller with injection pumps and solution tanks.
   a. Injector pumps shall operate to maintain required pH.
7. Install biocide feeder and injection pumps and solution tanks.
   a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection.

b. One pump is supplied for all systems (Tower, heating hot water, chilled water.)
c. Automatic ball valves shall be provided to only send chemicals to one system at a time.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General Valves for HVAC Piping."

E. See Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

F. See Section 232533 " HVAC Makeup water filtration Equipment for RO units and filter equipment.

3.4 ELECTRICAL CONNECTIONS

A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation, and calibrate controls during the preliminary phase of HVAC system's startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

D. Equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report, advising Owner of changes necessary to adhere to "Performance Requirements" Article for each required characteristic. Sample boiler water at four-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

G. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.

H. Comply with ASTM D3370 and with the following standards:

1. Silica: ASTM D859.
2. Steam System: ASTM D1066.
3. Acidity and Alkalinity: ASTM D1067.
4. Iron: ASTM D1068.
5. Water Hardness: ASTM D1126.

3.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for chilled-water piping, hot-water piping, steam and condensate piping, and condenser-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 Materials

A. Chemical treatment piping to be FEP tubing inside PVC conduit, except for the following:
1. Bleach piping before pump to be CPVC
2. Acid piping to be Kynaror Teflon lined CS
3. See chemical treatment P&ID for piping materials.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232500

SECTION 232533 - HVAC MAKEUP-WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following HVAC water-filtration equipment:
   1. Centrifugal separators.
   2. RO equipment for HVAC makeup water.

B. Related Requirements:

   1. Section 232500 "Water Treatment for HVAC Systems".

1.3 DEFINITIONS

A. RO: Reverse osmosis.

B. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
   1. Packaged Centrifugal separators.
   2. RO units.

B. Shop Drawings: Softeners and filtration equipment, maintenance space required, and piping connections to HVAC systems.

   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For water- filtration equipment units and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

C. Field quality-control reports.

D. Water Analysis: Illustrate water quality available at Project site.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, RO equipment, water-filtration units, and controllers to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PACKAGED CENTRIFUGAL SEPARATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Griswold Water Systems.
2. LAKOS Filtration Solutions.
3. PEP Filters, Inc.
4. Puroflux Corporation.
5. Rosedale Products, Inc.

B. Description: Skid Mounded pre-piped Packaged unit with simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity, side stream circulating end suction centrifugal pump, timer controlled centrifugal separator purge / drain valve, and purge water bag filter arranged for no-loss of water.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Housing: With manufacturer's proprietary system of baffles and chambers.

1. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
3. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
4. Collection Chamber: Designed to hold separated particles.
5. Outlet: Near top of unit.
6. Purge: At bottom of collection chamber.
7. Pipe Connections NPS 2 and Smaller: Threaded in accordance with ASME B1.20.1.
8. Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges in accordance with ASME B16.5 or grooved in accordance with AWWA C606. Provide stainless steel flanges if tank is stainless steel.

E. Motorized Purge Valve: Gate or plug pattern valve.

1. Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with EPDM valve seat and stem seal; with ASTM B148 aluminum bronze disc.

F. Strainer: Stainless steel basket type mounted on pump suction.

G. Piping: ASTM A53/A53M; Type S, F, or E; Grade B; Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding or ductile-iron fittings.

H. Piping: ASTM B88, Type L copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.

I. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.

1. Casing: Radially split, cast iron.
2. Pressure Rating: 150 psig minimum.
3. Impeller: ASTM B584 cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
5. Seal: Mechanical.
6. Motor: Open, drip proof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

J. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.

1. Panel: NEMA 250, Type 4 enclosure.

2. Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
3. Separator Purge: Automatic and manual.
4. TSS Controller Interlock: Open separator purge valve with bleed-off control.
5. Differential pressure switch for alarm when bag filter needs cleaned.

K. Support: Skid mounting. Fabricate supports, base, and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event, when separator base is anchored to building structure.

L. Chilled Water System Packaged Separator

1. Separator Design:

a. Tag: CHW-FLTR-1
b. Location: Side Stream Filter
c. Water-Flow Rate: 1,100 gpm.
d. Pressure Loss: 20 psig.
e. Separator Efficiency: 98 percent.
f. Particle-Specific Gravity: 2.6 Insert number.
g. Particle Size: 74 microns.

2. Housing:

a. Material: Steel or Stainless steel.
b. Pressure Rating: 150 psig.
c. LAKOS Model: TBX-1100-SRV-TC
d. Diameter: TBD.
e. Height: 85 inches.
f. Inlet Size: 6” NPS.
g. Outlet Size: 6” NPS.
h. Purge Size: 1 ½ NPS.

3. Circulating Pump:

a. Capacity:1100 gpm.
b. Total Dynamic Head: FEET.
c. Motor Speed: 1800 rpm.
d. Inlet Size: 8” NPT.
e. Outlet Size: 6” NPT.

4. Pump Motor Size and Electrical Characteristics:

a. Horsepower: 20 HP.
b. Volts: 480 V.
c. Phase: Three.
d. Hertz: 60 Hz.
e. Full-Load Amperes TBD.
f. Minimum Circuit Ampacity: TBD.
g. Maximum Overcurrent Protection: TBD.

5. BAG FILTER:

    a. Filter Design:
        1) Water-Flow Rate: TBD.
        2) Filtration Efficiency: 98 percent.
        3) Particle Size: 74 microns and larger.
        4) Clean Pressure Loss: 2 psig.
        5) Pressure Loss at Replacement: 6 psig.

    b. Housing:
        1) Material: Stainless steel.
        2) Pressure Rating: 150 psig.
        3) Seal Material: Nitrile rubber.
        4) Diameter: TBD.
        5) Height or Length: 33 inches.
        6) Inlet and Outlet Size: 1 1 /2NPS.
        7) Drain Size: 1 1/2” NPS.
        8) Bag Support Basket Material: Stainless steel.

    c. Filter Bag:
        1) Number Required: 1.
        2) Nominal Diameter: 8 inches.
        3) Nominal Length: 30 inches.
        4) Media Material: Polyester or Polypropylene.

M. Cooling Tower Water System Packaged Separator

1. Separator Design:

    a. Tag: CTW-FLTR-1
    b. Location: Side Stream Filter
    c. Water-Flow Rate: 825 gpm.
    d. Pressure Loss: 20 psig.
    e. Separator Efficiency: 98 percent.
    f. Particle-Specific Gravity: 2.6 Insert number.
    g. Particle Size: 74 microns.

2. Housing:

    a. Material: Steel or Stainless steel.
    b. Pressure Rating: 150 psig.
    c. LAKOS Model ; TBX-0825-SRV
    d. Diameter: TBD.
    e. Height: 85 inches.
    f. Inlet Size: 6 NPS.
    g. Outlet Size: 6NPS.
    h. Purge Size: 1 ½ NPS.

3. Circulating Pump:

    a. Capacity:825 gpm.

b. Total Dynamic Head: FEET.
c. Motor Speed: 1800 rpm.
d. Inlet Size: 8” NPT.
e. Outlet Size: 6” NPT.

4. Pump Motor Size and Electrical Characteristics:

a. Horsepower: 20 HP.
b. Volts: 480 V.
c. Phase: Three.
d. Hertz: 60 Hz.
e. Full-Load Amperes TBD.
f. Minimum Circuit Ampacity: TBD.
g. Maximum Overcurrent Protection: TBD.

5. BAG FILTER:

a. Filter Design:
1) Water-Flow Rate: TBD.
2) Filtration Efficiency: 98 percent.
3) Particle Size: 74 microns and larger.
4) Clean Pressure Loss: 2 psig.
5) Pressure Loss at Replacement: 6 psig.

b. Housing:
1) Material: Stainless steel.
2) Pressure Rating: 150 psig.
3) Seal Material: Nitrile rubber.
4) Diameter: TBD.
5) Height or Length: 33 inches.
6) Inlet and Outlet Size: 1 ½” NPS.
7) Drain Size: 1 1/2” NPS.
8) Bag Support Basket Material: Stainless steel.

c. Filter Bag:
1) Number Required: 1.
2) Nominal Diameter: 8 inches.
3) Nominal Length: 30 inches.
4) Media Material: Polyester or Polypropylene.

N. Cooling Tower Water System Basin Sweeper Packaged Separator

1. Separator Design:

a. Tag: CT-BS-FLTR-1 & CT-BS-FLTR-2
b. Location: Side Stream Filter
c. Water-Flow Rate: 610 gpm.
d. Pressure Loss: 20 psig.
e. Separator Efficiency: 98 percent.
f. Particle-Specific Gravity: 2.6 Insert number.
g. Particle Size: 74 microns.

2. Housing:

    a. Material: Steel or Stainless steel.
    b. Pressure Rating: 150 psig.
    c. LAKOS Model: eTBX-0610-SRV/ACP1 TC
    d. Diameter: TBD.
    e. Height: 85 inches.
    f. Inlet Size: 6” NPS.
    g. Outlet Size: 4” NPS.
    h. Purge Size: 1 ½ NPS.

3. Circulating Pump:

    a. Capacity:610 gpm.
    b. Total Dynamic Head: FEET.
    c. Motor Speed: 1800 rpm.
    d. Inlet Size: 6” NPT.
    e. Outlet Size: 4” NPT.

4. Pump Motor Size and Electrical Characteristics:

    a. Horsepower: 15 HP.
    b. Volts: 480 V.
    c. Phase: Three.
    d. Hertz: 60 Hz.
    e. Full-Load Amperes TBD.
    f. Minimum Circuit Ampacity:. TBD.
    g. Maximum Overcurrent Protection TBD.

5. BAG FILTER:

    a. Filter Design:
        1) Water-Flow Rate: TBD.
        2) Filtration Efficiency: 98 percent.
        3) Particle Size: 74 microns and larger.
        4) Clean Pressure Loss: 2 psig.
        5) Pressure Loss at Replacement: 6 psig.

    b. Housing:
        1) Material: Stainless steel.
        2) Pressure Rating: 150 psig.
        3) Seal Material: Nitrile rubber.
        4) Diameter: TBD.
        5) Height or Length: 33 inches.
        6) Inlet and Outlet Size: 1 ½” NPS.
        7) Drain Size: 1 1/2” NPS.
        8) Bag Support Basket Material: Stainless steel.

    c. Filter Bag:
        1) Number Required: 1.
        2) Nominal Diameter: 8 inches.

3) Nominal Length: 30 inches.
4) Media Material: Polyester or Polypropylene.

6. Basin Sweeper Alternating Kit

a. Multi tower basin control panel

1) 120 V, NEMA 4X panel with smart relays and programmable controls matched to number of cooling towers controlled. Control of basin sweeper piping motorized inlet and outlet control valves to direct water to cooling tower basin for effective tower basin sweeping.
2) Electronic control, staging and basin sweeping of up to four cooling tower towers.
3) Adjustable basin sweeper cycle time, or self-adjusting continuous basin alternation modes.
4) Motorized inlet and outlet control valves to match cooling tower requirements

O. Heating Hot Water System Packaged Separator

1. Separator Design:

a. Location: Side Stream Filter
b. Water-Flow Rate: 1,100 gpm.
c. Pressure Loss: 20 psig.
d. Separator Efficiency: 98 percent.
e. Particle-Specific Gravity: 2.6 Insert number.
f. Particle Size: 74 microns.

2. Housing:

a. Material: Steel or Stainless steel.
b. Pressure Rating: 150 psig.
c. Diameter: TBD.
d. Height: 85 inches.
e. Inlet Size: 8 NPS.
f. Outlet Size: 6 NPS.
g. Purge Size: 1 ½ NPS.

3. Circulating Pump:

a. Capacity:1100 gpm.
b. Total Dynamic Head: FEET.
c. Motor Speed: 1800 rpm.
d. Inlet Size: 8 NPT.
e. Outlet Size: 6 NPT.

4. Pump Motor Size and Electrical Characteristics:

a. Horsepower: 20 HP.

b. Volts: 480 V.
c. Phase: Three.
d. Hertz: 60 Hz.
e. Full-Load Amperes TBD.
f. Minimum Circuit Ampacity: TBD.
g. Maximum Overcurrent Protection: TBD.
h. Interrupting Capacity: TBD.

5. BAG FILTER:

a. Filter Design:
1) Water-Flow Rate: TBD.
2) Filtration Efficiency: 98 percent.
3) Particle Size: 74 microns and larger.
4) Clean Pressure Loss: 2 psig.
5) Pressure Loss at Replacement: 6 psig.

b. Housing:
1) Material: Stainless steel.
2) Pressure Rating: 150 psig.
3) Seal Material: Nitrile rubber.
4) Diameter: TBD.
5) Height or Length: 33 inches.
6) Inlet and Outlet Size: 1 ½" NPS.
7) Drain Size: 1 1/2" NPS.
8) Bag Support Basket Material: Stainless steel.

c. Filer Bag:
1) Number Required: 1.
2) Nominal Diameter: 8 inches.
3) Nominal Length: 30 inches.
4) Media Material: Polyester or Polypropylene

2.2 RO EQUIPMENT FOR HVAC MAKEUP WATER

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Basis of Design: Nancrede Engineering (www.necoindustrialwater.com, 317-257-7201) Marlo Incorporated. NECO Model NHC-9000-8 triplex

2. Aqua Systems, Inc.
3. Culligan International Company.
4. Diamond Water Systems, Inc.
5. Kinetico

B. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.

E. Skid Assembly: Welded-steel frame coated with epoxy protective finish.

F. RO Membrane and Housing:

1. Element: Thin-film composite with U-cup brine seal, with minimum 98 percent salt rejection based on 2000-ppm water supplied at 225 psig and 77 deg F.
2. Housing: ASTM A666, Type 304 stainless steel, with PVC end caps held in place with stainless-steel straps.

G. High-Pressure Pumps and Motors:

1. Pump:

a. Vertical, multistage, centrifugal pump, operating at 3500 rpm, with ASTM A666, Type 304 stainless steel casing, shaft, impellers, and inlet and discharge casting.
b. Bearings shall be tungsten carbide and ceramic.
c. Cast-iron frame and flanged suction and discharge connections.

2. Motor: NEMA-standard, C-faced, totally enclosed, fan-cooled motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

H. Controls:

1. Microprocessor-based controller with digital display.
2. Interlock for remote start/stop control.
3. Membrane flush sequence when pumps shut down.
4. Run time indicator.
5. Low-pressure safety cutoff.
6. Panel-mounted gages as follows:

a. Product and concentrate.
b. Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
c. Product conductivity monitor.

I. Valves:

1. Stainless steel pump, concentrate, and recycle throttling valves rated for minimum 300 psig.

2. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
3. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Provide sample valves at cartridge filter outlet, concentrate, and product outlet.

J. Prefilter:

1. Housing: Polypropylene with built-in relief or vent valve.
2. Element: Spun-wound polypropylene.

K. Inlet Water-Tempering Valve: Thermostatic water-tempering valve to maintain 77 deg F inlet water temperature to RO unit.

L. Activated Carbon Filter:

1. Media Tank: Fiberglass-reinforced polyester rated for minimum 150 psig with internal backwash distributor and filtered water collector.
2. Media: 12-by-40-mesh, bituminous coal-based activated carbon.
3. Backwash Valve: Piston-operated control valve with drain-line, flow-control orifice.
4. Backwash Control: Seven-day time clock.

M. Atmospheric Storage Tank:

1. Tank: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
2. Control: Level switches start and stop RO unit. Low-level limit shall stop repressurization pumps, and signal an alarm.

N. Repressurization Pumps:

1. Pumps: Two close-coupled, single-stage centrifugal pumps, with mechanical seals. Wetted components to be made of ASTM A666, Type 316 stainless steel.
2. Controls: NEMA 250, Type 4X pump control panel constructed of fiberglass to control pumps, one operating and one standby, with automatic alternator and fail-over control.
3. Motor: Open, drip-proof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

O. Water Test Kit: Include in wall-mounting cabinet for RO unit.

P. Capacities and Characteristics:

1. RO Product Flow Rate: 50 gpm
2. Total Water-Flow Rate: 67 gpm
3. Daily Water Consumption: 24,000 gal/day.
4. Water Demand: 24 hours/day.
5. Storage Tank Size: 3,000 gallons

6. RO Inlet Operating Temperature: 77 deg F .
7. High-Pressure Pump:

    a. Discharge Pressure: 150 psi
    b. Flow Rate: 68 gpm
    c. Horsepower: 15 HP
    d. Motor Speed: 3500 rpm.

8. Repressure Pumps:

    a. Discharge Pressure: 150 ft
    b. Flow Rate: 33
    c. Horsepower: 2
    d. Motor Speed: 3500 rpm.

9. Prefilter Design (at Total Water Flow Rate):

    a. Filter Efficiency: 98 percent.
    b. Particle Size: 5 microns and larger.
    c. Clean Pressure Loss: 2 psig.
    d. Replacement Pressure Loss: 6 psig.

10. Electrical Characteristics (Single-Point Connection):

    a. Volts: 480
    b. Phase: 3
    c. Hertz: 60
    d. Full-Load Amperes: 21
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection: <**Insert amperage**>.
    g. Interrupting Capacity: <**Insert amperage**>.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install equipment on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.2 RO UNIT INSTALLATION

A. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.

B. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.

C. Install water-testing sets on wall adjacent to RO unit.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-filtration equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping."

D. Connect cooling tower basin sweeper systems to cooling tower basin filter systems. Provide motor operated isolation valves in cooling tower basin sweeper piping inlet and outlet piping and wire to basin sweeper control panel. Adjust basin sweeper controls to rotate active cooling tower basin sweeping on timed basis (adjustable).

E. Install shutoff valves on HVAC water-filtration equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General Valves for HVAC Piping."

F. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

G. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

3.4 ELECTRICAL CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-filtration system into operation, and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:

1. Periodic field service and consultation.
2. Customer report charts and log sheets.
3. Laboratory technical analysis.
4. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 232533

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Requirements:

1. Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint devices and installation.
2. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Sustainable Design Submittals:

1. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data: For adhesives, indicating VOC content.

3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
4. Product Data: For sealants, indicating VOC content.
5. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
6. Laboratory Test Reports: For antimicrobial coatings, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of bottom of ducts.
5. Dimensions of all duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.
3. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports and seismic restraints are to withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. Seismically brace duct hangers and supports in accordance with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level (SHL): C.
2. Connection Level: 1.

B. Seismic Performance: Ductwork to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
1. Component Importance Factor: 1.5.
2. Component Amplification Factor =1.0
3. Component Response Modification Factor = 2.5.
4. Seismic Design Category C, Risk/Occupancy Category IV

C. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
3. Where specified for specific applications, all joints are to be welded.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.

1. Where specified for specific applications, all joints are to be welded.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

E. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. Verify sealant has a VOC content of 250 g/L or less.
11. Verify sealant complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Verify sealant has a VOC content of 250 g/L or less.
7. Verify sealant complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and is to be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

D. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.7 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A603, galvanized-steel cables with end connections made of galvanized-steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested in accordance with ASTM E488/E488M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class A.
4. Outdoor, Return-Air Ducts: Seal Class A.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class A.
8. Unconditioned Space, Return-Air Ducts: Seal Class A.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
11. Conditioned Space, Exhaust Ducts: Seal Class A.
12. Conditioned Space, Return-Air Ducts: Seal Class A.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2,

"Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint installation requirements.

3.6 DUCTWORK CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 2-Inch wg: Test entire installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.

5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing. Testing shall be observed by commissioning authority determined by Owner.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

G. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.9 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated in section 3.3 of this specification.

B. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

C. Elbow Configuration:

1. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

D. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 or Lower: Conical tap.
   b. Velocity 1000 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233119.13 - SHOP-FABRICATED HVAC CASINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Shop-fabricated casings.
2. Casing interstitial insulation.
3. Sealant materials.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For adhesives, indicating VOC content.
3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
4. Product Data: For sealants, indicating VOC content.
5. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
6. Laboratory Test Reports: For antimicrobial coatings, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For HVAC casings.

1. Include plans, elevations, sections, and attachment details.
2. Include details of HVAC casing assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

a. Sheet metal thickness(es).
b. Insulation.
c. Reinforcement and spacing.
d. Seam and joint construction.
e. Access doors including frames, hinges, and latches.
f. Locations for access to internal components.
g. Hangers and supports including methods for building attachment, vibration isolation, seismic restraints, and casing attachment.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for shop-fabricated HVAC casings, accessories, and components, from fabricator.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Welding certificates.

C. Product Certificates: For each type of casing.

1. For insulation properties, for the insulation material, and complete panel assembly, from fabricator.
2. For static-pressure ratings of complete panel assembly, from fabricator.
3. Product Certificates: For acoustical performance of each casing, from fabricator.

a. Show sound-absorption coefficients in each octave band. Coefficients to be equal to or lower than those scheduled when tested in accordance with ASTM C423.
b. Show airborne sound transmission losses. Losses to be equal to or lower than those scheduled when tested in accordance with ASTM E90.

4. Casing Performance: Submit calculations indicating that the proposed casing construction will achieve the required static-pressure classification, acoustical performance, and structural performance.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for casing joint and seam welding.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of steel supports. Supports are specified in Section 055000 "Metal Fabrications."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Static-Pressure Classes:

1. Upstream from Generator Radiator Fans: -2 inch wg.
2. Downstream from Generator Radiator Fans: +2 inch wg.

B. Thermal Performance for Assembled Casing Panel:

1. 2-Inch Panel: 0.12 Btu/h x sq. ft. x deg F.

C. Acoustical Performance for Assembled Casing Panel:

1. NRC: 1.09 in accordance with ASTM C423.

D. Structural Performance:

1. Fabricate casings to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch/foot.

E. Flammability:

1. Insulation and Other Materials Exposed to the Airstream:

a. All materials exposed to the airstream to comply with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

G. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

H. Seismic Performance: Casing to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

2.2 GENERAL CASING FABRICATION REQUIREMENTS

A. General Casing Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 9, "Equipment and Casings," for acceptable construction details related to required static-pressure classes.

B. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 9, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Fabricate casings in accordance with SMACNA's "Rectangular Industrial Duct Construction Standards."

D. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Exterior-Surface Galvanized Coating Designation: G90.
2. Interior-Surface Galvanized Coating Designation: G90.

E. Stainless Steel: ASTM A480/A480M, Type 304, and having a No. 2D finish.

F. Shop-Applied Antimicrobial Coating:

1. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
2. Use only antimicrobial compound tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating Hardness: 2H minimum when tested in accordance with ASTM D3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 in accordance with UL 723; certified by an NRTL.
5. Applied Coating Color: Standard.

G. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

H. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.

I. Access Doors: Fabricate access doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 9-15, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 9-16, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and in accordance with pressure class of the plenum or casing section in which access doors are to be installed.

1. Size: 36 by 72 inches.
2. Vision Panel: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
3. Hinges: Piano or butt hinges and latches; number and size in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Latches: Minimum of two wedge-lever-type latches; operable from inside and outside.
5. Neoprene gaskets around entire perimeters of door frames.
6. Install doors to open against air pressure.

2.3 SHOP-FABRICATED CASINGS

A. Double-Wall Casings: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

1. Outer Panel: Galvanized sheet steel.

B. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.

C. Fabricate close-off sheets from casing to dampers or sound attenuators. Use G90 galvanized sheet steel of same thickness as outer casing.

D. Bolt close-off sheets to frame flanges and housings. Sound attenuators supported on stands fabricated from galvanized-steel angles or channels as specified on structural drawings and specifications.

E. Reinforce casings with galvanized-steel angles.

F. Double-Wall Casing Inner Panel, Perforated: Galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

2.4 CASING INTERSTITIAL INSULATION

A. Casing insulation is used to fill the interstitial void between inner and outer panel wall in double-wall casing construction and provides thermal and acoustic insulation.

B. Interstitial Insulation, Polyurethane-Foam and Fibrous-Glass Combination: Polyurethane foam in combination with fibrous glass for enhanced sound absorption characteristics.

1. Polyurethane-Foam Insulation Thickness: 1 inch.
2. Fibrous-Glass Insulation Thickness: 1 inch.
3. Maximum Thermal Conductivity of Composite Panel: 0.1 Btu x in/h x sq. ft. x deg F at 75 deg F mean temperature.
4. Coat insulation with antimicrobial coating.
5. Cover insulation with polyester film complying with NFPA 701.

2.5 SEALANT MATERIALS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets to have a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. Verify sealant has a VOC content of 250 g/L or less.
7. Verify sealant complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
8. Maximum Static-Pressure Class: 10 inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel or stainless steel.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single component, acid curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Verify sealant has a VOC content of 420 g/L or less.
7. Verify sealant complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine concrete bases and steel supports for compliance with requirements for conditions affecting installation and performance of HVAC casings. Verify that there is sufficient clearance for access and to install all ductwork, and other fittings.

B. Examine casing insulation materials and liners before installation. Reject casings that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install casings in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Equipment Mounting:

1. Where indicated on Drawings, install HVAC casings on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Apply sealant to joints, connections, and mountings.

D. Field-cut openings for pipe and conduit penetrations through casing walls; insulate and seal in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

F. Support casings on base or foundation system. Secure and seal to base.

G. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.

H. Align casings accurately at connections, with 1/8-inch misalignment tolerance and with smooth interior surfaces.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections with the assistance of a shop-authorized service representative.

C. Tests and Inspections:
   1. Inspect all casing access doors and other openings having movable covers, demonstrating that they are reasonably accessible, open and close fully without binding or excessive fiction, and when fully closed, they seal properly.
   2. Perform field tests of the following systems:
      a. Air Inlet Monitor Plenum: 100 percent of total installed casing area (Both Rooms).
      b. Generator Room Plenum: 100 percent of total installed casing area (Both Rooms).

   3. Conduct tests at generator radiator fan induced static pressures with all generators being tested simultaneously. Do not pressurize system above maximum design operating pressure. Give seven days' advance notice for testing.
   4. Disassemble, reassemble, and seal segments of system to accommodate leakage testing and for compliance with test requirements.

D. HVAC casings will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 CLEANING

A. Comply with requirements for cleaning in Section 233113 "Metal Ducts."

END OF SECTION 233119.13

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Flange connectors.
6. Turning vanes.
7. Duct-mounted access doors.
8. Duct access panel assemblies.
9. Flexible connectors.
10. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
3. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless

otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.
2. NCA Manufacturing, Inc.; Metal Industries, Inc.
3. Nailor Industries Inc.
4. Pottorff.
5. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

B. Description: Gravity balanced.

C. Performance:

1. Maximum Air Velocity: 2500 fpm.
2. Maximum System Pressure: 4 inches wg.
3. AMCA Certification: Test and rate in accordance with AMCA 511.
4. Leakage:
   a. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.

D. Construction:

1. Frame:

   a. Hat shaped.
   b. 18-gauge-thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.

2. Blades:

   a. Multiple single-piece blades.
   b. End pivoted, maximum 6-inch width, 0.070-inch-thick aluminum sheet with sealed edges.

3. Blade Action: Parallel.

E. Blade Seals: Extruded vinyl, mechanically locked.

F. Blade Axles:

1. Material: Nonmetallic.
2. Diameter: 0.50 inch.

G. Tie Bars and Brackets: Aluminum.

H. Return Spring: Adjustable tension.

I. Bearings: synthetic pivot bushings.

J. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Greenheck Fan Corporation.
b. Nailor Industries Inc.
c. Pottorff.
d. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

2. Performance:

a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Construction:

a. Linkage out of airstream.
b. Suitable for horizontal or vertical airflow applications.

4. Frames:

a. Hat-shaped, 16-gauge-thick, galvanized sheet steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized steel; 16 gauge thick.

6. Blade Axles: Nonferrous metal.
7. Bearings:

    a. Molded synthetic.
    b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.

8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

B. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

A. See section 230923.12 for Control Damper Specifications. Control damper installed by Mechanical Contractor. Actuators installed by temperature controls contractor.

2.5 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.
2. NCA Manufacturing, Inc.; Metal Industries, Inc.
3. Pottorff.
4. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

B. Type: Static; rated and labeled in accordance with UL 555 by an NRTL.

C. Fire Rating: 1-1/2 hours.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed galvanized sheet steel, interlocking full-length steel blade connectors. Material gauge is to be in accordance with UL listing.

H. Horizontal Dampers: Include blade lock and stainless steel closure spring.

I. Heat-Responsive Device:

1. Replaceable, 165 deg F rated, fusible links.

2.6 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. DynAir; a Carlisle Company.
4. Ward Industries; a brand of Hart & Cooley, LLC.

B. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gauge and Shape: Match connecting ductwork.

2.7 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. Duro Dyne Inc.
4. DynAir; a Carlisle Company.
5. Ward Industries; a brand of Hart & Cooley, LLC.

B. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. Vane Construction:
1. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.8 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. Duro Dyne Inc.
4. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
5. Ward Industries; a brand of Hart & Cooley, LLC.

B. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. 22-gauge-thick galvanized steel door panel.
d. Vision panel.
e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
f. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

a. 22-gauge-thick galvanized steel frame.

3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.

    a. 22-gauge-thick galvanized steel door panel.

2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0 to 8.0 inches wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 2-inch- thick, fibrous-glass or polystyrene-foam board.

2.9 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. Flame Gard, Inc.

B. Panel and Frame: Minimum thickness 16-gauge carbon steel.

C. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.

D. Minimum Pressure Rating: 10 inches wg positive or negative.

2.10 FLEXIBLE CONNECTORSManufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. Duro Dyne Inc.
4. DynAir; a Carlisle Company.
5. Ward Industries; a brand of Hart & Cooley, LLC.

B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Materials: Flame-retardant or noncombustible fabrics.

E. Coatings and Adhesives: Comply with UL 181, Class 1.

F. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 24 gauge thick, galvanized sheet steel. Provide metal compatible with connected ducts.

G. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 30 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

H. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 30 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.11 DUCT ACCESSORY HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. Duro Dyne Inc.
4. DynAir; a Carlisle Company.
5. Ward Industries; a brand of Hart & Cooley, LLC.

B. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

C. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.12 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and No. 2 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts.

1. Install steel volume dampers in steel ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install fire dampers in accordance with UL listing.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. At drain pans and seals.
3. Downstream from control dampers, backdraft dampers, and equipment.
4. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
5. At each change in direction and at maximum 50-ft. spacing.
6. Upstream and downstream from turning vanes.
7. Control devices requiring inspection.
8. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:
1. Head and Hand Access: 12 by 12 inches.
2. Head and Shoulders Access: 20 by 16 inches.
3. Body Access: 24 by 24 inches.

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233346 - FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Non-insulated flexible ducts.
2. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For adhesives and sealants, indicating VOC content.
3. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.
4. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
5. <Double click to insert sustainable design text for LEED 2009 Prerequisite EA2.>

C. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flexmaster U.S.A., Inc.
2. JP Lamborn Co.
3. McGill AirFlow LLC.
4. Thermaflex; a Flex-Tek Group company.
5. Ward Industries; a brand of Hart & Cooley, LLC.

B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1.

2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

B. Non-Clamp Connectors: Adhesive.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

D. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with adhesive.

F. Install duct test holes where required for testing and balancing purposes.

G. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

H. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 233346

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Axial roof ventilators.
   2. Centrifugal ventilators - roof downblast.
   3. Centrifugal ventilators - roof upblast.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
   2. Rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Certified fan performance curves with system operating conditions indicated.
   4. Certified fan sound-power ratings.
   5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   6. Material thickness and finishes, including color charts.
   7. Dampers, including housings, linkages, and operators.
   8. Prefabricated roof curbs.
   9. Fan speed controllers.

B. Shop Drawings:

   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: Submit certificates that specified equipment will withstand required wind forces, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions

1. Base fan-performance ratings on the following:

a. Ambient Temperature: 70 deg F.
b. Altitude: 770 ft above sea level.
c. Humidity: 55 deg F.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Seismic Performance: HVAC power ventilators shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

G. Wind Performance: Air-handling units shall withstand the effects of wind determined in accordance with to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

2.2 AXIAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerovent; a division of Twin City Fan Companies, Ltd.

2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. New York Blower Company (The).
5. PennBarry; division of Air System Components.

B. Housing: Heavy-gauge, removable, rectangular, ribbed hood style; square, one-piece, hinged, aluminum base.

C. Fan blades: Welded and die formed steel blades.

D. Direct Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

E. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum wire.
3. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator by temperature controls contractor; wired to close when fan stops where indicated. See schedules and temperature controls diagrams on drawings.

F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 24 inches.
3. Pitch Mounting: Manufacture curb for roof slope.
4. Metal Liner: Galvanized steel.
5. Mounting Pedestal: Galvanized steel with removable access panel.

2.3 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. New York Blower Company (The).
5. PennBarry; division of Air System Components.

B. Housing: Downblast; removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades; spark-resistant construction classified in accordance with AMCA 99, Section 8, Type C where indicated. See schedules on drawings.

D. Accessories, See schedules for specific equipment to receive accessories listed:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator by temperature controls contractor; wired to close when fan stops where indicated. See schedules and temperature controls diagrams on drawings.
4. Spark-resistant, all-aluminum wheel construction where indicated. See schedules on drawings.
5. Hinged sub-base to provide access to damper or as cleanout for grease applications.

E. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 24 inches.
3. Pitch Mounting: Manufacture curb for roof slope.
4. Metal Liner: Galvanized steel.

2.4 CENTRIFUGAL VENTILATORS - ROOF UPBLAST

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. New York Blower Company (The).
5. PennBarry; division of Air System Components.

B. Configuration: Centrifugal roof upblast ventilator.

C. Housing: Removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Accessories, See schedules for specific equipment to receive accessories listed:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator by temperature controls contractor; wired to close when fan stops where indicated. See schedules and temperature controls diagrams on drawings.
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.

F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 24 inches.
3. Pitch Mounting: Manufacture curb for roof slope.
4. Metal Liner: Galvanized steel.

2.5 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.

D. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install power ventilators level and plumb.

B. Equipment Mounting:

1. Secure roof-mounted fans to roof curbs with stainless steel hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

D. Install control and electrical power wiring to field-mounted control devices.

E. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.4 STARTUP SERVICE:

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper

thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Lubricate bearings.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.6 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.
3. Fans and components will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233423

SECTION 233516.13 - POSITIVE PRESSURE ENGINE EXHAUST SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes specifications for furnishing and installing factory-built Engine Exhaust Systems.

1.3 SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

2. Include:
   a. Catalog cuts
   b. Sizing calculations
   c. Installation drawings
   d. Installation instructions
   e. Sample of extended warranty
   f. Evidence of internal static pressure listing

1.4 QUALITY ASSURANCE

A. Applicable standards:

1. All products furnished under this Section shall conform to the requirements of NFPA-37 and NFPA 211. Products shall be listed to UL 103 and shall carry the appropriate UL and cUL listing mark or label.

B. Warranty:

1. The Engine Exhaust System shall be warranted by the manufacturer against defects in material and workmanship for a period of one (1) year, with the option of an extended twelve (12) years, from the date of original installation. Any

portion of the exhaust system repaired or replaced under warranty shall be warranted for the remainder of the original warranty period.

PART 2 - PRODUCTS

2.1 ENGINE EXHAUST SYSTEM

A. The engine exhaust system shall be of the double-wall, factory-built type for use with diesel engines or turbines as described in NFPA 37 which produce exhaust at temperatures not exceeding 1400ºF continuously or 1800ºF intermittently.

B. Engine exhaust system shall be listed for an internal static pressure of 60 inches w.g.

C. The exhaust pipe sections shall be constructed of an inner wall and an outer wall with a 1” insulating air space.

1. The inner wall shall be constructed of .035” thick type 304 stainless steel for diameters 6” through 36” and .048” thick for diameters 38” through 48”.
2. The outer wall shall be constructed of .024” thick aluminized steel for sizes 6” through 24” and .034” thick for sizes 26” through 48”.
3. Inner and outer walls shall be connected by means of spacer clips which maintain the concentricity of the annular space and allow unobstructed, differential thermal expansion of inner and outer walls.

D. All exhaust pipe parts exposed to the atmosphere shall be protected by one (1) coat of corrosion and heat resistant primer and one (1) coat heat resistant paint.
1. NOTE: In areas where fumes may be present in the vicinity of the exhaust system, Type 316 stainless steel outer wall is recommended.

E. All supports, drains, roof penetrations, terminations, flange adapters, and fittings required to install the exhaust pipe shall be included. Lined bellows joints shall be used to compensate for expansion. Provide relief valve where indicated on plans.

F. All inner pipe joints shall be held together by means of formed vee bands and sealed with PO71, High Temperature Sealant.

1. Where exposed to weather, the outer bands shall be sealed with P077 Silicone Sealant to prevent rain water from entering the space between the inner and outer walls. Paint shall be furnished and applied by installer.
2. Screws shall be of the hex head type with shoulder stops and tapered 'lead-in' threads for easy starting.
3. Nuts for the inner and outer bands shall be retained by means of a free-floating cage to allow easy alignment.
4. Seal clips should be used in conjunction with vee bands on diameters 6 thru 10 inch.

G. Exhaust system shall terminate three feet above roof or as required by local codes.

H. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Duravent Group.
2. Metal-Fab, Inc.
3. Security Chimneys International.

PART 3 - EXECUTION

3.1 GENERAL

A. Store delivered materials inside, out of the weather. Protect materials from accidental damage or vandalism.

B. Installation shall conform to the manufacturer's installation instructions, UL listing and state or local codes.

C. Support chimney from building structure using rigid structural shapes for attachment of fixed point supports (Plate Support Assembly). Anchor supports to structure by welding, bolting, steel expansion anchors, or concrete inserts. Size of structural shapes shall be in accordance with manufacturer's recommendations.

D. Protect uncompleted chimney installations by attaching temporary closures over open ends of sections.

E. Clean all chimneys and breechings of dust and debris prior to final connection to appliances.

F. Installation shall conform to manufacturers installation instructions.

END OF SECTION 233516.13

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Modulating, single-duct air terminal units.
   2. Casing liner.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

B. Sustainable Design Submittals:

   1. Product Data: For adhesives, indicating VOC content.
   2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
   3. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For air terminal units.

   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: For air terminal units, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.

B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

A. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

2.2 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Global Corporation.
2. Johnson Controls, Inc.
3. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
6. Price Industries Limited.
7. Titus; brand of Johnson Controls International plc, Global Products.
8. Trane.
9. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.

B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: Minimum 20-gauge- thick galvanized steel.

1. Casing Liner: Comply with requirements in "Casing Liner" Article below for "Casing Liner, Fibrous Glass" Paragraph with "Solid Metal Liner" Subparagraph.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 1.5 percent of nominal airflow at 6-inch wg inlet static pressure.

E. Velocity Sensors: Multipoint array with velocity inlet sensors.

F. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.

G. Direct Digital Controls:

1. Terminal Unit Controller: Terminal unit controller shall be provided to air terminal unit manufacturer by temperature controls contractor for factory mounting. Controll shall be pressure-independent, VAV controller with integrated actuator.Electronic airflow transducer with multipoint velocity sensor at air inlet from air terminal unit manufacturer shall be factory calibrated to minimum and maximum air volumes.

a. Occupied and unoccupied operating mode.
b. Remote reset of airflow or temperature set points.
c. Adjusting and monitoring with portable terminal.
d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2. Room Sensor: Room sensor shall be provided and installed by temperature controls contractor. Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

H. Control Sequence: See Drawings for control sequences.

2.3 CASING LINER

A. Casing Liner, Fibrous Glass: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A or NFPA 90B, and with NAIMA AH124.

1. Minimum Thickness: 1 inch.

a. Maximum Thermal Conductivity:
1) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Solid Metal Liner: Solid galvanized sheet metal encapsulating matted insulation face from airstream.
3. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

a. Verify adhesive has a VOC content of 80 g/L or less.
b. Verify adhesive complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.4 SOURCE QUALITY CONTROL

A. AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.

B. Water Coils: Factory pressure test to 300 psig in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "Metal Ducts" for hangers and supports.

B. Install air terminal units according to NFPA 90A.

C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

D. Temperature controls contractor shall provide and install wall-mounted thermostats.

3.2 PIPING CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply piping with shutoff valve, strainer, control valve, and union or flange; and to return piping with balancing valve and union or flange.

3.3 DUCTWORK CONNECTIONS

A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

3.4 ELECTRICAL CONNECTIONS

A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows, and coil type. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713.13 - AIR DIFFUSERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air Diffusers:
   a. Louver face diffusers.
   b. High-capacity drum louver diffusers.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for volume-control dampers not integral to diffusers.
2. Section 233713.23 "Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 AIR DIFFUSERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Krueger-HVAC, a division of Air System Components; Johnson Controls, Inc.
2. METALAIRE, Inc.
3. Nailor Industries Inc.
4. Price Industries.
5. Titus, a division of Air System Components; Johnson Controls, Inc.
6. Tuttle & Bailey, a division of Air System Components; Johnson Controls, Inc.

2.2 LOUVER FACE DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material: Aluminum with ½" mineral fiber, foil scrim vapor barrier insulated backpan.

C. Finish: Baked enamel, white.

D. Face Size: 24 inches by 24 inches.

E. Mounting: Surface or T-bar. See reflected ceiling drawings for mounting application.

F. Pattern: Four-way core style.

G. Dampers: Radial opposed blade.

2.3 HIGH-CAPACITY DRUM LOUVER DIFFUSERS

A. Airflow Principle: Extended distance for high airflow rates.

B. Material: Aluminum, heavy gage extruded.

C. Finish: White baked acrylic.

D. Border: 1-1/4-inch (32-mm) width with countersunk screw holes.

E. Gasket between drum and border.

F. Body: Drum shaped; adjustable vertically.

G. Blades: Individually adjustable horizontally.

H. Mounting: Surface to duct.

I. Inlet Width: See plans.

J. Inlet Length: See plans.

K. Accessories:

1. Integral opposed-blade steel damper.
2. Duct-mounting collars with countersunk screw holes.
3. Integral pitch adjustment rotating body.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

SECTION 233713.23 - GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Fixed face grilles.
2. Linear bar grilles.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to grilles.
2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 GRILLES

A. Egg Crate Grilles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Carnes Company.

b. Krueger-HVAC, a division of Air System Components; Johnson Controls, Inc.
c. Nailor Industries Inc.
d. Price Industries.
e. Titus, a division of Air System Components; Johnson Controls, Inc.
f. Tuttle & Bailey, a division of Air System Components; Johnson Controls, Inc.

2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Arrangement: Perforated core.
5. Core Construction: Integral.
6. Frame: 1 inch wide.
7. Mounting: Countersunk screw or Lay in. See reflected ceiling drawings for mounting application.
8. Accessory: Filter.

B. Louvered Grilles

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Carnes Company.
b. Krueger-HVAC, a division of Air System Components; Johnson Controls, Inc.
c. Nailor Industries Inc.
d. Price Industries.
e. Titus, a division of Air System Components; Johnson Controls, Inc.
f. Tuttle & Bailey, a division of Air System Components; Johnson Controls, Inc.

2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Horizontal; spaced 3/4 inch apart.
5. Core Construction: Integral.
6. Distribution plenum.

a. Internal insulation.
b. Inlet damper.

7. Frame: 1-1/4 inches wide.
8. Mounting: Countersunk screw.
9. Damper Type: Adjustable opposed blade.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

SECTION 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Louvered-penthouse ventilators.
2. Hooded ventilators.
3. Goosenecks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For gravity ventilators.

1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates for ventilators, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.6 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

B. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."

E. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

2.2 FABRICATION

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3 HOODED VENTILATORS

A. Description: Hooded rectangular penthouse for intake and relief air.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carnes Company.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. PennBarry; division of Air System Components.
5. Twin City Fan & Blower.

C. Source Limitations: Obtain hooded ventilators from single manufacturer.

D. Construction:
1. Material, Aluminum: Thickness required to comply with structural performance requirements, but not less than 0.063-inch-thick base and 0.050-inch-thick hood; suitably reinforced.
2. Insulation: None.
3. Bird Screening: Aluminum, 1/2-inch-square mesh or flattened, expanded aluminum, 3/4-inch diamond mesh wire.

E. Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.

F. Dampers:

1. Location: Hood neck.

G. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 36 inches.

2.4 SOURCE QUALITY CONTROL

A. AMCA Certification for Hooded Ventilators: Test, rate, and label gravity ventilators in accordance with AMCA 511.

2.5 MATERIALS

A. Aluminum Extrusions: ASTM B221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B209, Alloy 3003 or 5005, with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

D. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Secure gravity ventilators to roof curbs with hardware described in Part 2, that comply with the wind and seismic fastening requirements. Use concealed anchorages where possible. Refer to Section 077200 "Roof Accessories."

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses.

F. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes, so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

I. Refer to Section 077200 "Roof Accessories" for flashing and counterflashing of roof curbs.

3.2 DUCT CONNECTIONS

A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts". Drawings indicate general arrangement of ducts and duct accessories.

3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

END OF SECTION 233723

SECTION 235133 - INSULATED SECTIONAL CHIMNEYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Listed chimney liners.
2. Listed building-heating-appliance chimneys.
3. Guying and bracing materials.

B. Related Requirements:
1. 235239 Fire Tube Boilers

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For chimneys and stacks.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Seismic Qualification Certificates: For factory-fabricated chimneys and stacks, accessories, and components from manufacturer.

C. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in stacks.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED BUILDING-HEATING-APPLIANCE CHIMNEYS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Cleaver-Brooks.
2. DuraVent.
3. Heatfab Saf-T Vent.
4. Industrial Chimney Company.
5. Metal-Fab, Inc.

B. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F continuously or 1700 deg F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 2-inch annular space filled with high-temperature, ceramic-fiber insulation.

D. Inner Shell: ASTM A666, Type 304 stainless steel.

E. Outer Jacket: Stainless steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: No loss exit cap with drain section incorporated into riser.
2. Provide draining tee at bottom of exhaust riser.

2.2 GUYING AND BRACING MATERIALS

A. Cable: Four galvanized, stranded wires of the following thickness:
1. For ID Sizes 18 to 24 Inches: 3/8 inch.

B. Angle Iron: Four galvanized steel, 2 by 2 by 0.25 inch or manufacturer’s designed roof band for supporting chimneys.

PART 3 - EXECUTION

3.1 APPLICATION

A. Steam Boiler Exhaust: Listed Building-Heating-Appliance Chimneys as noted in this specification.

3.2 INSTALLATION OF LISTED CHIMNEYS

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

D. Lap joints in direction of flow.

E. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

F. Provide temporary closures at ends of chimneys and stacks that are not completed or connected to equipment.

END OF SECTION 235133

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Provide boiler vent in accordance with Section 235123 "Gas Vents."

1.2 SUMMARY

A. Section includes dual-fuel, gas-fired, fire-tube floor-mounted condensing boilers, trim, and accessories for generating hot water.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For boilers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Product Certificates:

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. CSA B51 pressure vessel Canadian Registration Number (CRN).

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period. Where "prorated" is indicated, the boiler manufacturer will cover the indicated percentage of cost of replacement parts. With "prorated" type, covered cost decreases as age of equipment increases.

1. Warranty Period for Floor-Mounted Fire-Tube Condensing Boilers:

a. Heat Exchanger and Tank: Free from defects in material and workmanship.
b. Warranty Coverage: Prorated Year 0 to 5 - 100 percent; Year 6 to 7 - 50 percent; Year 8 to 9 - 30 percent; Year 10 - 10 percent for 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency in accordance with Table 6.8.1-6 and other requirements in Ch. 6 of ASHRAE/IES 90.1.

D. Mounting Base: For securing boiler to concrete base

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined below when mounting base is anchored to building structure.

E. Seismic Performance: Boiler shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term “withstand” means “the boiler will remain in place without separation of any parts when subjected to the seismic forces specified and the boiler will be fully operational after the seismic event.”
2. Component Importance Factor: 1.5.
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

2.2 FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aerco
2. Cleaver-Brooks
3. Riello Boiler
4. Superior Boiler

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

C. Heat Exchanger: Corrosion-resistant Type 316 stainless steel.

D. Pressure Vessel: Carbon steel with welded heads and tube connections. Boiler pressure vessel to be built to ASME Boiler and Pressure Vessel Code for a minimum design pressure rating of 150 PSIG.

E. Burner: Dual fuel (gas and No. 2 fuel oil), forced draft.

F. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Powder-coated protective finish.
4. Insulation: Minimum 2-inch-thick, mineral-fiber or polyurethane-foam insulation surrounding the heat exchanger.

J. Capacities and Characteristics:

1. Heating Medium: Hot water.
2. Design Water-Pressure Rating: 160 psig.
3. Safety Relief Valve Setting: 160 psig
4. Entering-Water Temperature: 100 deg F.
5. Leaving-Water Temperature: 130 deg F.
6. Design Water Flow Rate: 630 gpm.
7. Minimum Water Flow Rate: 150 gpm.
8. Design Pressure Drop: 2 psig.
9. Minimum Thermal Efficiency: 92 percent.
10. Gross Output Capacity: 10000 MBH.
11. Electrical Characteristics:

a. Volts: 460 V.
b. Phase: Three.
c. Hertz: 60 Hz.
d. Full-Load Amperes: 23 A.
e. Minimum Circuit Ampacity: 29 A.
f. Maximum Overcurrent Protection: 52 A.

2.3 TRIM

A. Include devices sized to comply with ASME B31.9.

B. Aquastat Controllers: Operating, firing rate, and high limit with automatic reset.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch-diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. High and low gas-pressure switches.

F. Boiler Air Vent: Automatic.

G. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

2.4 CONTROLS

A. See drawings for sequence of operations.

B. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: All set points shall be adjustable.
3. Electric, factory-fabricated and field-installed panel to control burner-firing rate, maintain supply-water temperature at 130 deg F with a user adjustable setback for seasonal adjustment.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

C. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Automatic reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch factory mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

D. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. A BACnet communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. All monitoring and control features, which are available at the local boiler control panel, shall also be available at the remote operator workstation through the building automation system.

2.5 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to fused disconnect switch.
5. Provide branch power circuit to each motor and to controls.
6. Provide each motor with overcurrent protection.

2.6 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

2.7 CONDENSATE-NEUTRALIZATION UNITS

A. Description: Factory-fabricated and -assembled condensate-neutralizing tank assembly of corrosion-resistant plastic material with threaded or flanged inlet and outlet pipe connections. Device functions to prevent acidic condensate from damaging grain system. It is to be piped to receive acidic condensate discharged from condensing boiler and neutralize it by chemical reaction with replaceable neutralizing agent. Neutralized condensate is then piped to suitable drain. Provide unit for each direct boiler condensate drain and additional units for the bottom of the main flue risers. Flue neutralization can utilize a single unit for multiple drains as capacity allows. See plans for location and quantities.

B. Tank features:

1. All corrosion-resistant material.
2. Suitable for use on natural gas boilers.
3. Includes initial charge of neutralizing agent.
4. Neutralizing agent to be easily replaceable when exhausted.
5. Inlet and outlet pipe connections.

C. Tank Configuration:
1. Top easily removed for neutralizing agent replacement.
2. Internal baffles to channel flow for complete neutralization.
3. Integral bypass to prevent condensate backflow into appliance.
4. Multiple units may be used for larger capacity.

2.8 SOURCE QUALITY CONTROL

A. UL Compliance: Test gas-fired boilers having input of more than 400,000 Btu/h for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

B. UL Compliance, Gas-Fired: Test gas-fired boilers for compliance with UL 2764. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

C. UL Compliance, Oil-Fired: Test oil-fired boilers for compliance with UL 726. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

D. Performance Testing: Test and label boilers for efficiency to comply with AHRI 1500.

E. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

F. Test and inspect factory-assembled boilers, before shipping, in accordance with 2017 ASME Boiler and Pressure Vessel Code. Factory test boilers for safety and functionality; fill boiler with water, and fire throughout firing range, to prove operation of all safety components.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install floor-mounted boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 PIPING CONNECTIONS

A. Comply with requirements for hydronic piping specified in Section 232113 "Hydronic Piping."

B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

C. Drawings indicate general arrangement of piping, fittings, and specialties.

D. When installing piping adjacent to boiler, allow space for service and maintenance of condensing boilers. Arrange piping for easy removal of condensing boilers.

E. Install condensate drain piping to condensate-neutralization unit and from neutralization unit to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.

F. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

G. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve, and union or flange at each connection.

H. Install piping from safety relief valves to nearest floor drain.

3.4 DUCT CONNECTIONS

A. Boiler Venting:
1. Comply with all manufacturer's installation instructions.
2. Utilize vent material, size, and configuration as indicated in boiler manufacturer's instructions and to comply with UL 1738.
3. Connect boiler vent full size to boiler connections.
4. Comply with requirements in Section 235123 "Gas Vents."

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. Perform installation and startup checks in accordance with manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. For dual-fuel boilers, perform tests for each fuel.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Boiler will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

1. Instructor shall be factory trained and certified.
2. Provide not less than two hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION 235216

SECTION 235239 - FIRE-TUBE BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. See 235133 Insulated Sectional Chimneys for steam boiler exhaust flues.

1.2 SUMMARY

A. Section includes horizontal, packaged, factory-fabricated and -assembled fire-tube boilers, trim, and accessories for generating steam.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:
   1. Construction details, material descriptions, dimensions, and weights of individual components, profiles, and finishes for boilers.
   2. Rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Predicted boiler efficiency while operating at design capacity and at varying part loads with basis indicated.
   4. Predicted emissions levels while operating at design capacity and at varying part loads with basis indicated. Indicate operation that produces worst-case emissions.
   5. Technical data for refractory and insulation, including temperature rating, thermal performance, attachment, and arrangement.
   6. Calculations showing predicted surface temperature of boiler jacket with basis indicated.
   7. Force and moment capacity of each piping and flue connection.
   8. Dimensioned location of low, high, and normal water level, showing operating set point and each alarm set point.
   9. Temperature and pressure rating, size, and materials of construction for boiler trim components, including piping, fittings, flanges, unions, and valves. Provide valve manufacturer's product data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.
   10. Manufacturer's product data showing size, scale range, and accuracy of thermometers and pressure gages.
   11. Pressure rating, size, and materials of construction for boiler fuel train components including piping, fittings, flanges, unions, switches, and valves. Provide manufacturer's product data for each valve and switch furnished.

12. Detailed information of controls, including product data with technical performance, operating characteristics, and sequence of operation.
13. Product data for each motor, including performance, operating characteristics, and materials of construction.

B. Shop Drawings: For boilers, boiler trim, and accessories.
1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection
3. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For boilers, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Installation instructions.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

F. Other Informational Submittals:
1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

B. Spare Parts List: Recommended spare parts list with quantity for each.

C. Touch-up Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.

D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Tool kit to include the following:
   1. A tool kit specially designed by boiler manufacturer for use in servicing boiler(s) furnished.
   2. Special tools required to service boiler components not readily available to Owner service personnel in performing routine maintenance.
   3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Boiler Tool Kit." Text size shall be at least 1 inch high.
   4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 0.5 inch high.

B. Touch-up Paint: 32 oz. container of paint used for finish coat. Label on outside of container shall have a detailed description of paint to allow for procurement of a matching paint in the future.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Ship boilers from the factory free of water. Drain water and blow dry with compressed air if required to remove all water before shipping.

B. Cover and protect flue, electrical controls, and piping connections before shipping. Protect and seal openings and connections with blinds, caps, plugs, and other materials during delivery, storage, and handling.

C. Protect boiler components with removable temporary enclosures to prevent damage during shipping, storage, and installation.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace front- and rear-door refractories and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.
   1. Horizontal Fire-Tube Boilers: Refractory in front and rear doors, 10 years from date of startup by factory-authorized personnel.

B. Warranty of all other equipment to be 2 years for material and labor after Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fuel-to-steam efficiency indicated shall be based on the following:
   1. ASME Performance Test Code (PTC) 4, Heat Loss method.
   2. Test Operating Conditions:
      a. Ambient Temperature: 80 degrees F.
      b. Ambient Relative Humidity: 30%
      c. Percent Excess Air in Exhaust Flue Gas: 15 firing natural gas.
      d. Fuel Heating Value 1,000 to 1,090 BTU/CuFt (Natural Gas)

B. Gas-Fired Boiler Emissions: Not to exceed allowable ambient air quality standards in governing jurisdiction and indicated values.
   1. Carbon monoxide:
      a. 50 parts per million at any point from 100 percent to 50 percent fire.
      b. 100 parts per million at any point below 50percent fire.
   2. Nitrogen compounds: 30 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
   3. Sulfur compounds: One part per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
   4. Hydrocarbon and Volatile Organic Compounds: 20 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
   5. Particulate Matter: 0.01 lb/MMBtu.
   6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.

C. Oil-Fired Boiler Emissions: Not to exceed allowable ambient air quality standards in governing jurisdiction and indicated values.
   1. Carbon monoxide:
      a. 50 parts per million at any point from 100 percent to 50 percent fire.
      b. 100 parts per million at any point below 50percent fire.
   2. Nitrogen compounds: 90 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
   3. Sulfur compounds: One part per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
   4. Hydrocarbon and Volatile Organic Compounds: 30 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
   5. Particulate Matter: 0.015 lb/MMBtu.
   6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.

D. Multiple Boiler Operation: Equip individual boilers in multiple boiler applications with integral controls to provide multiple boiler operation for optimum system performance, energy efficiency, and the following:
   1. Equalize runtime of boilers in service.
   2. Operate multiple boilers hot to minimize disruption of service in the event of single boiler failure.
   3. Configure controls so any boiler can be taken out of service with power disconnected and not impact multiple boiler operation.

E. Seismic Performance: Boiler shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term “withstand” means “the boiler will remain in place without separation of any parts when subjected to the seismic forces specified and the boiler will be fully operational after the seismic event.”
   2. Component Importance Factor: 1.5.
   3. Component Amplification Factor =1.0
   4. Component Response Modification Factor = 2.5.
   5. Seismic Design Category C, Risk/Occupancy Category IV
   6.

F. Steam Quality: 99.5 percent dry and saturated.

G. Operation Following Loss of Normal Power:
   1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a back-up power source or through normal power if restored before back-up power is brought online.
   2. Provide means and methods required to satisfy requirement even if not explicitly indicated.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

J. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

K. UL Compliance: Test Boilers for compliance with UL 726 and UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

2.2 HORIZONTAL FIRE-TUBE BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cleaver-Brooks.(Basis of Design: CBEX-2W-700)
   2. Hurst Boiler & Welding Company, Inc.
   3. Superior Boiler Works, Inc.
   4. Victory Energy

B. Pressure Vessel Design: Wet-back design with the following:
   1. Two or Four pass(es).
   2. Minimum Heat-Exchanger Surface: As required to achieve performance indicated.

3. Provisions for lifting boiler in-place.

C. Base:
1. Factory-mounted pressure vessel and other boiler components on steel saddles or supports that are fastened securely to a structural steel base that is constructed to make a complete self-supported unit requiring only a flat level surface for support.
2. Base included with attachments if required to secure boiler to structure.
3. Manufacturer's standard provisions for lifting include the following.
   a. Designed for handling and installation conditions encountered.
   b. Sufficient to carry total weight of fully assembled boiler with a safety factor of 1.2.

D. Shell:
1. Horizontal, cylindrical, steel pressure vessel of size to satisfy performance requirements indicated.
2. Manholes and Handholes:
   a. Manhole for waterside inspection and access.
   b. Handholes at front and rear of boiler for waterside inspections.
   c. According to 2010 ASME Boiler and Pressure Vessel Code.
3. Steam Boilers:
   a. Connections for steam supply, feedwater, level controls, and chemical treatment.
   b. Baffle in shell below steam outlet to provide dry steam with no water carry over.
   c. Bottom and surface blowdown connections.
   d. Connections with safety relief valve(s), drains and exhaust stack.

E. Furnace:
1. Welded cylindrical steel chamber that is welded to steel tube sheets.
2. Arranged to provide uniform heat distribution under all firing conditions with no flame impingement on any refractory-covered or waterbacked surface.
3. Surrounded by water without interfering with natural circulation of water within shell.
4. Positioned from shell to inhibit unequal thermal stresses during operation.

F. Fire Tubes:
1. Steel, seamless or resistance welded.
2. Fitted in accurately sized holes in tube sheets and rolled or welded in place.
3. Aligned to prevent noticeable deformation with undue stress when boiler is put in service.
4. Tube and tube sheet assembly shall be water- and gastight.
5. Arranged not to interfere with natural circulation of water in shell or to inhibit cleaning and flushing of water sides.
6. Readily removable from one or both end(s) of boiler.
7. Provided without spinners, turbulators, and other inserted devices.

G. Flue:

1. Flanged connection located along top centerline of boiler and capable of supporting a field-installed flue stack with a weight of at least **2000 lb**.
2. Equip boiler flue with bimetal thermometer in a stainless-steel case, with angle position adjustment and nominal 5-inch diameter face having a graduated scale and range of approximately 1.5 times the outlet temperature. Mount thermometer in a Type 316 stainless-steel thermowell that is located in a visible location to indicate flue-gas temperature.

H. Front and Rear Doors:
1. Hinged or davited, sealed with heat-resistant gaskets and fastened with lugs and cap screws.
2. Designed so tube sheets and flues are fully accessible for inspection or cleaning when doors are open without the need to disconnect burner, blower, and fuel piping.
3. Include observation ports in doors at both ends of boiler for inspection of flame conditions.
4. Door refractory and insulation shall be accessible for inspection and maintenance.
5. Reinforce doors of dryback boilers to limit deflection due to thermal stresses and burner combustion pulsations to prevent progressive cracking and loosening of refractory.

I. Refractories:
1. Refractories retained shall withstand temperature occurring under maximum load conditions.
2. Formed or cast-in sections shall be easily replaceable through factory openings.
3. Secure refractory sections in position to withstand vibration and shock occurring during shipment, and to withstand burner combustion pulsations.
4. Where used for the burner combustion ring and rear or target baffle, refractories shall have a parametric cone equivalent of not less than 33.
5. Provide refractory for doors and end covers exposed to temperatures of **600 deg F** and higher.

J. Insulation:
1. Minimum 2-inch- thick, mineral-fiber insulation surrounding the boiler shell and secured in place to prevent sagging or displacement.
2. Insulation of sufficient density or attached with reinforcement to prevent permanent deformation of protective jacket when subjected to an impact force of <**Insert value**> and forces associated with service personnel walking, kneeling, and laying on boiler while performing service.

K. Jacket: Sheet metal, with factory-applied protective finish.
1. Nominal Thickness: Not less than 0.048 inch.
2. Preformed shape to follow a smooth and uniform contour of pressure vessel and encapsulating insulation.
3. Consisting of multiple removable sections attached with corrosion-resistant screw-fasteners to facilitate removal and replacement multiple times.
4. Painted after assembly.

2.3 BURNER

A. Burner designed to fire combination gas and oil.

B. Welded construction with multivane, stainless-steel, flame-retention diffuser.

C. Single-tip retractable nozzle for low-pressure air-atomizing burner.

D. Mount burner to permit unrestricted access to combustion chamber.

E. Burner Operation: full modulating control to return to low-fire position for ignition.
1. Gas-Fired Burner: 10 to 1 turndown.
2. Oil-Fired Burner: 8 to 1 turndown.

F. Burner Fuel Combustion Efficiency: Minimum 99.9 percent.

G. Gas Pilot: Premix type with automatic electric ignition, complete with electronic flame scanner to monitor the pilot, so primary fuel valve cannot open until pilot flame has been established.

H. Oil Pilot: Intermittent electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with UV scanner flame-safety control.

I. Manual adjustments not required to operate at varying loads.

J. Performance shall be repeatable after changes in firing rate.

K. Control devices and sequence shall comply with NFPA 85 or UL requirements.

L. Damper: Designed to provide accurate control of combustion air with minimum hysteresis. Damper shall close when boiler is off.

2.4 BLOWER

A. Combustion air supplied by a forced-draft blower assembly that is isolated to reduce vibration and noise.

B. Mount blower to permit unrestricted access to combustion chamber.

C. Centrifugal type, with a forward-curve, backward-inclined airfoil or radial blade wheel.

D. Blower and drive assembly shall be controlled through boiler's integral controls in response boiler manufacturer's prescribed sequence of operation that is coordinated with burner and fuel train to achieve performance indicated.
1. Where indicated or required to achieve performance, provide blower with unit-mounted variable-frequency controller to vary blower speed in response to prescribed control set point and changes in operating conditions.

2. Variable-speed fan operation shall be checked for resonant frequencies and adjusted to provide no resonant frequencies throughout entire operating range.

E. Blower Drive Assembly: Direct drive.

F. Blower Motor:
1. General Requirements: Comply with requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:
a. Efficiency: Premium efficient.
b. Enclosure: totally enclosed, fan cooled.
c. Insulation Class: F
d. Service Factor: 1.15.
e. Motors operated through variable-frequency controllers shall be inverter duty rated according to NEMA MG-1.
2. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.5 GAS TRAIN

A. Comply with Owner insurance underwriter requirements. In absence of specific requirements, comply with more stringent requirements indicated.

B. Pilot gas piping train shall include:
1. One manually operated, lubricated plug cock or ball valve upstream of all valves and accessories.
2. One pressure regulator with vent.
3. Pressure gage located downstream of pressure regulator. Nominal 4-inch diameter face with graduated scale to indicate gas pressure. Gage shall have normal operating pressure of about 50 percent of full range.
4. Primary and secondary automatic valves to operate simultaneously.
5. Normally open, full port electrically operated valve in a vent pipe connected between automatic valves.
6. Manually operated valve with threaded plug located downstream of both automatic gas valves to permit leakage testing.

C. Main gas piping train shall include:
1. Threaded pressure tapping with threaded plug upstream and downstream of valve and regulator.
2. One manually operated, lubricated plug cock, ball valve, or butterfly valve upstream and downstream of all valves and accessories.
3. One main pressure regulator with vent.
4. Primary and secondary automatic valves to operate simultaneously.
5. Manually operated gas valve with threaded plug located downstream of both automatic gas valves to permit leakage testing.
6. Normally open, full port electrically operated valve in a vent pipe connected between automatic valves.

7. Pressure gage with isolation valve located upstream and downstream of pressure regulator and at inlet to burner. Nominal 4-inch diameter face with graduated scale to indicate gas pressure. Gage shall have normal operating pressure of about 50 percent of full range.
8. Proof of closure switch for each motor-operated valve and pressure regulator.
9. Low-gas-pressure and high-gas-pressure switch.

D. Control devices and sequence shall comply withNFPA 85 orULrequirements.

E. Main gas valves shall be wired to close automatically in the event of power failure, low water level, or any safety shutdown condition.

F. Mount pilot and main gas trains on side of boiler and support from boiler base.

2.6 OIL TRAIN

A. Comply with Owner insurance underwriter requirements. In absence of specific requirements, comply with more stringent requirements indicated.

B. Control devices and sequence shall comply with NFPA 85 orULrequirements.

C. Oil Pump:
1.
2. Oil Pump to be by others.

D. Low-Pressure Air-Atomizing System:
1. Separate air compressor module, factory furnished and shipped loose for field installation, with burner-mounted, low-atomizing-air-pressure switch.
2. Complete system for each burner, furnished by burner manufacturer, including compressor, drive, air filter, after cooler, low-pressure switch, and piping.
3. Low-air-pressure switch interlocked to prevent burner operation if air pressure failure occurs.
4. Motor shall comply with requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

E. Oil Burner Piping:
1. Factory-installed fuel oil piping shall include the following:
   a. Oil-pressure-regulating devices.
   b. Oil metering controls.
   c. Low-oil-pressure switch.
   d. Two motorized oil valves.
   e. Pressure gauges.

F. Piping Specialties:
1. Suction-line, manual shutoff valve.
2. Removable-mesh strainer.
3. Oil Filter: Oil filter with permanent edge-type elements that are cleanable by rotation of a handle without interruption to flow.

a. Element Spacing: 0.0035 inch.
b. Maximum Pressure Loss:3 psig
c. Provide with plugged drain.

4. 0- to 30-inch Hg vacuum; 0- to 30-psig vacuum-pressure gage.
5. oil-nozzle pressure gage.
6. Nozzle-line, solenoid-safety-shutoff oil valve.
7. Relief valve located in discharge piping of oil pump with valve discharge connected to oil pump suction piping.

G. Main piping shall include the following (in order, starting at field connection and moving to burner):
1. Manual shutoff valve.
2. Removable-mesh strainer.
3. Oil filter.
4. Pressure gage with isolation valve.
5. Pressure regulator.
6. Low-pressure switch.
7. High-pressure switch.
8. Flow meter.
9. Flow control valve.
10. Thermometer.
11. Valved drain.
12. Automatic safety shutoff valve.
13. Valved leak test.
14. Manual shutoff valve.
15. Pressure gage with isolation valve.

H. Mount train on side of boiler and support from boiler base.

2.7 FLUE-GAS RECIRCULATION

A. Equip boiler with packaged flue-gas recirculation system if required to satisfy emission requirements.

B. Complete package integrating burner, combustion-air blower and damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.

2.8 STEAM BOILER TRIM

A. Include devices sized to comply with ASME B31.1.

B. Pressure Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve:
1. Size and Capacity: As required for equipment according to 2010 ASME Boiler and Pressure Vessel Code.

2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
   a. Drip-Pan Elbow: Cast iron and having flanged or threaded inlet and outlet with threads complying with ASME B1.20.1.

D. Pressure Gage: Nominal 6-inch diameter face with graduated scale and siphon, with isolation valve to indicate pressure vessel steam pressure. Gage shall have boiler normal operating pressure of about 50 percent of full range and an accuracy of 0.5 percent.

E. Bimetal Thermometer: Stainless-steel case with angle position adjustment and nominal 5-inch diameter face having a graduated scale with a range of approximately 1.5 times the outlet temperature. Mount thermometer in a Type 316 stainless-steel thermowell to indicate steam temperature inside pressure vessel.

F. Water Column: Minimum 10-inch reflex glass gage with gage rods to protect glass, ball check and shutoff cocks, water column blowdown valves, and vacuum breaker. Midpoint of gage shall be at normal operating water level.

G. Bottom Blowdown Valves: Factory-installed, duty-rated, slow-acting blowdown valves and interconnecting piping same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ASME B31.1.

H. Surface Blowdown Valves: Factory-installed, duty-rated isolation valves and interconnecting piping. In addition, provide electrically operated control valve, duty rated, to control total dissolved solids (TDS) through boiler controls.

I. Stop Valves: Boiler outlets, except safety relief valves, shall be equipped with duty-rated stop valve in an accessible location as near as is practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 shall have rising stem.

J. Stop-Check Valves: Factory-installed, duty-rated stop-check valve and stop valve at boiler outlet with free-blow drain valve field installed between the two valves and visible when operating stop-check valve.

K. Feedwater Valves: Factory-installed, three-valve bypass arrangement with modulating control valve positioned between duty-rated stop valves, bypass piping with throttling valve, check valve, and interconnecting piping. Stop and throttling valves larger than NPS 2 shall have rising stem. Modulating control valve shall have the following features and characteristics:
   1. Duty rated with electric operator to control water level through boiler controls.
   2. Equal percentage flow characteristic.
   3. Valve Flow: 1.25 times boiler output.
   4. Valve Pressure and Temperature Rating: Equal to boiler.
   5. Shut-off Leakage: 0.01 percent of valve coefficient.

L. Chemical Injection Assembly: Factory-installed, duty-rated injection quill with ball check valve and isolation valve compatible with dispensed chemical.

M. Sample Cooler: Factory furnished for field installation, with needle valve for each connection. Constructed of Type 316 stainless steel.

2.9 CONTROLS

A. Boiler operating controls shall include the following devices and features:
   1. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
   2. Set-Point Adjust: Operating and alarm set points shall be field adjustable.

B. Pressure Control for Steam Boilers:
   1. Operating-Pressure Control: Factory wired and mounted to control boiler to maintain boiler at constant pressure within 3 percent of set point.
   2. High-Pressure Cutoff with Automatic Reset: Control stops burner if operating conditions rise above normal operating-pressure set point. Set point shall be adjustable.
   3. High-Pressure Cutoff with Manual Reset: Control stops burner operation upon reaching adjustable high limit set point that is below safety valve setting.

C. Water-Level Control for Steam Boilers:
   1. Operating Water-Level Control: Operate feedwater pump(s) continuously and modulate boiler feedwater valve in response to water level for water-level control.
   2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
   3. Auxiliary Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
   4. Microprocessor-based control.
   5. Accuracy within 0.01 inch.
   6. Visual indication of level, alarms, and errors through alphanumeric display.
   7. Features:
      a. Continuous water-level indication.
      b. Low-water cutoff and alarm.
      c. High-water alarm.
      d. Low- and high-water warning.
      e. Control of feedwater pump.
      f. Control of modulating feedwater control valve.
      g. Continuous monitoring of float operation.
      h. Column blowdown detection and reminder.
      i. Auxiliary low-water cutoff check.
      j. Auto and manual reset.
      k. Alarm annunciation.

D. Multiple Boiler Operation: Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

E. Boiler Emergency Shutdown: Interlock with field-installed boiler emergency shutdown switch to shut down boiler when activated. Manufacturer to furnish break-glass-type switch with permanent nameplate titled "Boiler Emergency Shutdown" for field installation.

F. Chemical Feed System Interface: Dry contacts to interface control and operation of chemical feed pump.

G. Burner Safety Controls for Steam Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.
   1. High Cutoff: Automatic and Manual reset stops burner if operating conditions rise above maximum boiler operating pressure.
   2. Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
   3. Auxiliary Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
   4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

H. Burner Flame Safeguard Controls:
   1. Factory equipped with flame safeguard control and infrared flame scanner.
   2. Microprocessor-based, solid-state control having sequence and flame-on visual indication and fault code indications of flame safeguard trip functions.
   3. Control shall include dynamic self-check logic.
   4. Control shall have a fixed operating sequence incapable of being manually altered that includes start, prepurge, pilot and main fuel ignition run, and postpurge cycles.
   5. Control shall be nonrecycle type for maximum safety that shall shut down the burner and indicate, as a minimum, the following trip functions:
      a. Pilot and main flame failure.
      b. High- and low-fire proving switch faults.
      c. Running interlocks open.
      d. False flame signal and fuel valve open.
   6. Control shall include a run/test switch to allow interruptions to sequence just after prepurge and during pilot ignition trial, and run cycles for adjustments to firing rate motor, damper linkages, and pilot flame for minimum turndown tests.

I. Combustion-Air Controls: Factory equipped with motor-operated combustion-air damper and blower control to regulate burner fire according to load demand.

J. Oxygen Trim Control:
   1. Provide oxygen trim system to continuously monitor and display oxygen concentrations in boiler flue gas and adjust fuel and airflow to maintain an adjustable oxygen-level set point.
   2. System shall compensate for changes in ambient temperature, barometric pressure, humidity, and variations in fuel characteristics.

K. Surface Blowdown Control: Provide a conductivity sensor and control circuitry to operate an automatic control valve in surface blowdown piping to maintain total dissolved solids (TDS) within boiler manufacturer's prescribed level.

L. Building Automation System Interface: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.
   1. Communication Interface: ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control on/off and capacity of boiler and monitor the boiler operation from an operator workstation. Control features are available, and monitoring points are displayed locally at boiler-control panel through the interface.

M. Integrated Boiler-Control System:
   1. Integral control of burner management for flame safety, boiler modulation, and operator interface functions with features and functions indicated.
   2. Factory preconfigured.
   3. Utilizing solid-state controls and sensors to provide various control functions, including the following:
      a. Automatic sequencing of the boiler through standby, prepurge, pilot flame establishing period, main flame establishing period, run, flame proving and lockout, and postpurge.
      b. Full modulating control of air and fuel through Proportional-Integral-Derivative (PID) algorithm.
      c. Thermal shock protection.
      d. High and low limit alarms and shutdowns.
   4. Local operator interface through nominal 10-inch color touch screen graphical display for setup, monitoring, and data acquisition.
      a. Manual control of the boiler firing rate using control screens to increment or decrement firing rate.
      b. Indication of burner management controller status and diagnostics.
      c. Display of system alarms and faults.
      d. Display of history of alarms and faults.
      e. Display of recommendations for troubleshooting of fault conditions.
      f. Display of water-level indication and alarm(s).
      g. Stack flue-gas, combustion-air, and shell water-temperature indication.
      h. Boiler efficiency calculation and display.
      i. Low-fire hold with minimum temperature control.
      j. Assured low-fire cutoff (ALFCO).
      k. High stack temperature annunciation with auto cutoff.
      l. Audible alarm and silencing through touch screen intervention.
   5. Fully integrated control of the following:
      a. Blower operation and combustion-air damper for varying operating conditions.
      b. Oxygen trim and monitoring to compensate for combustion-air variations.
      c. Parallel positioning for independent fuel and air control for enhanced fuel efficiency.
      d. Multiple boiler lead/lag control with hot standby.
   6. LAN/WAN interface with remote monitoring software to allow remote monitoring independent of control system interface.

N. Control Enclosures:
   1. NEMA 250, Type 12.

a. Provide enclosure with integral vents, fans, heater, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.

2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
3. Mounted on boiler assembly at a location convenient to operator.
4. Provide hinged full-size door with key lock. Provide common key for all locks.
5. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls and other section shall house line voltage controls.
6. Enclosure shall house the following:
   a. Control transformers with fuses.
   b. Labeled terminal strips.
   c. Controller(s) to provide control and alarm functions indicated.
   d. Audible indication of safety alarms.
7. Face of enclosure shall provide the following:
   a. Visual indication of operating components and alarms.
   b. Auto/local capability to allow operator to manually operate boiler locally.
   c. Audible alarm-silence capability.
   d. Labels for switches, lights, and displays to provide clear indication of service.

O. Control Instrument Enclosures: Control instruments and devices that are mounted on the boiler assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.

P. Control Cable and Wire:
1. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
2. Install cable and wiring located outside of enclosure(s) in a metal raceway. Use flexible conduit to make final terminations. Provide watertight installation for applications exposed to moisture.

2.10 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
1. Enclosure: NEMA 250, Type 12.
   a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
   b. Mounted on boiler assembly at a location convenient to operator.
   c. Enclosure shall have hinged full-size door with key lock with common key for all locks.
2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.

3. Install wiring outside of an enclosure in a metal raceway. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
4. Field power interface shall be to nonfused disconnect switch. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
7. Provide transformer with fuses and power wiring to power a 20-A 120-V duplex receptacle mounted in each boiler control panel for use in connecting analytical and testing equipment.
8. Provide uninterruptible power supply for boiler control package during transfer of emergency power.

2.11 FINISH

A. General:
1. Paint boiler, using manufacturer's standard procedures, except comply with requirements indicated.
2. Miscellaneous surfaces shall be finished to match continuous surfaces.
3. Manufacturer shall field touch up or entirely repaint surface finishes, which were damaged during shipment, to original condition, using original materials and methods.
4. Paint shall be suitable for temperatures encountered on painted surfaces.
5. Requirements indicate minimum quality level. Provide more robust paint system if required to comply with other requirements indicated.

B. Do not paint aluminum or stainless steel.

2.12 FLUE-GAS ECONOMIZER

A. Provide heat exchanger to transfer heat from boiler flue gas to boiler feedwater.

B. Type: Rectangular configuration with replaceable finned tubes, arranged for up-flow flue gas and parallel flow water.

C. Internal Bypass: Economizer furnished with an internal bypass diverter to provide emergency bypass operation, with no external ducting, for controlling the following:
1. Stack corrosion.
2. Turndown performance.
3. Excessive flue-gas backpressure due to fouling.

D. Construction:

1. Comply with 2010 ASME Boiler and Pressure Vessel Code.
2. Design for abnormal operation with no water in tubes at temperature indicated.
3. Design Pressure:
   a. Water Tubes: 300 psig.
   b. Inner Casing: 10 inches wc
   c. Design Temperature: 700 deg F
4. Tubes and Headers:
   a. ASTM A254, Type 316 stainless steel.
   b. Helically wound, nonserrated stainless-steel fins continuously welded to tubes.
   c. Arrange tubes to permit cleaning by soot blowing.
   d. Fin Density: 48 fins per foot
   e. Fin Height: 0.5 inch
   f. Return bend areas shall be exposed to the bulk temperature of the flue gas.
   g. Headers shall be external to the casing.
   h. Flanged piping connections.
   i. Drainable by gravity.
5. Casing:
   a. Double wall, with removable panels and insulation between inner and outer casing. Access panels shall allow access to tubes and internal bypass diverter for cleaning and replacement.
   b. Casing shall be gas tight.
   c. Inner Casing: Stainless steel, all welded.
   d. Insulation: Mineral fiber, 2 inch thick.
   e. Outer Casing: Galvanized, stainless or painted carbon steel.
   f. Angle flanges on flue-gas inlet and outlet for attachment of breeching and stack.

E. Accessories:
1. Inlet and Outlet Transitions: Designed by economizer manufacturer and furnished with economizer.
2. Safety Relief Valve: Selected by economizer manufacturer according to 2010 ASME Boiler and Pressure Vessel Code requirements.
3. Soot Blowers: Steam-operated, rotating valve-in-head. Provide sufficient number to clean all tube areas. Location, arrangement, and quantity based on recommendations of soot blower manufacturer for type and size of economizer furnished.
4. Thermometers:
   a. Water Inlet and Discharge Thermometers: Bimetal thermometer in a stainless-steel case with angle position adjustment, nominal 5-inch diameter face having graduated scale and range of approximately 1.5 times the discharge temperature. Mount thermometer in a Type 316 stainless-steel thermowell that is located in a visible location to indicate water inlet and discharge temperature.
   b. Flue-Gas Inlet and Discharge Thermometers: Bimetal thermometer in a stainless-steel case with angle position adjustment, nominal 5-inch diameter face having graduated scale and range of approximately 1.5 times the inlet temperature. Mount thermometer in a Type 316 stainless-steel thermowell

that is located in a visible location to indicate flue-gas inlet and discharge temperature.

F. Factory Test and Inspections:
1. Inspect completed economizer assembly according to 2010 ASME Boiler and Pressure Vessel Code.
2. Certify inspection and submit completed ASME form for each economizer.

2.13 CAPACITIES AND CHARACTERISTICS

A. Heating Medium: Steam.

B. Design Pressure Rating: 150 psig.

C. Safety Relief Valve Setting: 150 psig.

D. Steam Operating Pressure: 125 psig.

E. Steam-Flow Rate: 24,150 lb/h.

F. Fuel-to-Steam Efficiency: 84.5 percent w/economizer.

G. Number of Passes: Two

H. Gas Input Flow: 28,580 cfh.

I. Gas Pressure: 5 psig.

J. Oil Input Flow: 198 gph

K. Output Capacity: 24,150 MBh.

L. Flue-Gas Economizer:
1. Design Feedwater Flow: 48 gpm
2. Design Feedwater Pressure Drop: 1 psig.
3. Entering-Feedwater Temperature: 212 deg F
4. Leaving-Feedwater Temperature: 241 deg F
5. Design Flue-Gas Flow: 5604 cfm.
6. Design Flue-Gas Pressure Drop: .5 wc.
7. Entering-Flue-Gas Temperature: 413 deg F.
8. Leaving-Flue-Gas Temperature: 311 deg F.

M. Burner Blower:
1. Motor Horsepower: 50 hp.

N. Electrical Characteristics:
1. Volts: 460 V.
2. Phase: Three.

3. Hertz: 60 Hz.
4. Full-Load Amperes: A.
5. Minimum Circuit Ampacity: A.
6. Maximum Overcurrent Protection: A.

2.14 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

B. Burner and Hydrostatic Test:
1. Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve performance requirements indicated.
2. Perform hydrostatic test of pressure vessel, piping, and trim of assembled boiler.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and flue; piping; controls; and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
1. Boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for flue, piping, controls, and electrical connections.

B. Examine areas where boilers will be installed for suitable conditions.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Equipment Mounting:
1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Install gas-fired boilers according to NFPA 54.

D. Install oil-fired boilers according to NFPA 31.

E. Assemble and install boiler trim, components, and accessories that are not factory installed.

F. Install control and electrical devices furnished with boiler that are not factory mounted.

G. Install control and power wiring to field-mounted control and electrical devices furnished with boiler that are not factory installed.

H. Perform boil-out and cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Following boil-out and cleaning procedures, boiler shall be washed and flushed until water leaving boiler is clear.

I. Protect boiler fireside and waterside from corrosion.
   1. Before boiler is filled with water, protect by dry storage method recommended by boiler manufacturer.
   2. After boiler is filled with water, and left not fired for more than 10days, protect by wet storage method recommended by boiler manufacturer.
   3. Chemical Treatment: Quality of water in boilers shall be maintained by a professional water-treatment organization that shall provide on-site supervision to maintain the required water quality during periods of boiler storage as well as during operating, standby, and test conditions.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to boiler(s), allow space for service and maintenance.

C. Connect gas piping to boiler gas-train inlet with dirt leg, shutoff valve, and union or flange. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

D. Connect oil piping to oil-train connection with dirt leg, shutoff valve, and union. Piping shall be at least full size of oil-train connection. Provide a reducer if required. Provide drain valve with threaded plug at piping low point.

E. Connect steam and condensate piping to supply-, return-, and blowdown-boiler connections with union or flange at each connection. Provide each connection with shutoff valve if shutoff valves are not factory furnished with boiler trim. Provide check valves in blowdown piping of each boiler that connects multiple boilers.

F. Connect feedwater piping to inlet- and discharge-flue-gas economizer connections with union or flange at each connection. Provide each connection with shutoff valve and other accessories indicated and recommended by manufacturer.

G. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.

H. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

I. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.
   1. Provide a temperature-controlled nonpotable domestic cold water source to cool hot equipment drains to deliver a discharge temperature of 140 F

J. Connect chemical-treatment piping to each boiler chemical-treatment connection with check valve and isolation valve.

3.4 FLUE CONNECTIONS

A. Connect breeching to full size of boiler outlet. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" and Section 235133 "Insulated Sectional Chimneys" for venting materials.

B. Install flue-gas recirculation duct from vent to burner if not factory furnished and installed. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for recirculation duct materials.

C. Install easily accessible test ports for field testing of flue gas from each boiler.

D. Install flue-gas economizer with factory-furnished transitions to connect to boiler and to field-installed breeching.

3.5 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between boilers and other equipment to interlock operation as required, to provide a complete and functioning system.

C. Connect control wiring between boiler control interface and DDC control system for remote monitoring and control of boilers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.7 NETWORK AND PHONE CONNECTIONS

A. Connect LAN/WAN network cable to boiler controls to provide connectivity for remote monitoring through integrated boiler control system.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:
   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Hydrostatic Leak Test: Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and steam pressure.
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Boiler will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to twovisits to Project during other-than-normal occupancy hours for this purpose.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Video training sessions and provide electronic copy of video to Owner. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235239

SECTION 235316 - DEAERATOR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. SECTION 230923.11 – CONTROL VALVES

1.2 SUMMARY

A. Section includes packaged, factory-assembled deaerator.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. Feedwater Pump: Pump that moves boiler feedwater from the deaerator to the boiler.

C. NPSHR: Net-positive suction head required.

D. Transfer Pump: Pump that moves boiler feedwater from the condensate receiver to the deaerator.

1.4 ACTION SUBMITTALS

A. Product Data: For each unit to include the following:

1. Equipment performance and operating characteristics, such as rated makeup water, feedwater, steam condensate and steam flow rates; working pressure; tank capacities, storage capacity in minutes; temperature and NPSHR; and pump performance curves with selection points clearly indicated.
2. Furnished specialties and accessories.
3. Construction details, material descriptions, dimensions and weight of individual components, and profiles and finishes.
4. Force and moment capacity of each field piping connection.
5. Dimensioned location of low, high, and normal water level showing operating set point and each alarm set point.
6. Temperature and pressure rating, size, and materials of construction for trim components including, piping, fittings, flanges, unions, and valves. Provide valve

manufacturer Product Data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.

7. Manufacturer Product Data showing size, scale range, and accuracy of thermoinstruments and pressure gauges.
8. Detailed information of controls including Product Data with technical performance, operating characteristics, and sequence of operation.
9. Product Data for each motor, including performance, operating characteristics, and materials of construction.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For deaerator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Startup service reports.

D. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to deaerator.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For deaerator, components, and accessories to include in emergency, operation, and maintenance manuals.

B. Spare Parts List: Recommended spare parts list with quantity for each.

C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.

D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Gaskets: Furnish one replacement gasket(s) for each gasketed opening.
2. Gauge Glass: Furnish one replacement glass(es) for each gauge glass.
3. Pump Mechanical Seal Set: Furnish one replacement mechanical seal set(s) for each unique pump mechanical seal.

B. Tool Kit:

1. A tool kit specially designed by deaerator manufacturer for use in servicing deaerator(s) furnished.
2. Special tools required to service deaerator components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Deaerator Tool Kit." Text size shall be at least 1 inch high.
4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 0.5 inch high.

C. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Ship deaerator from the factory free of water. Drain water and blow deaerator dry with compressed air if required to remove all water before shipping.

B. Cover and protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping, storage, and handling.

C. Cover and protect electrical and control devices and open connections.

D. Comply with manufacturer's written rigging instructions.

E. Deliver deaerator as factory-assembled units with protective crating and covering. Deaerator vessel and elevating stand assembly to be separated for shipment and reassembly in field. Connections of all components and equipment disassembled for

shipment shall be match-marked at factory prior to disassembly for ease of reassembly in field.

F. Protect deaerator components with removable temporary enclosures to prevent damage during shipping, storage, and installation.

1.9 WARRANTY

A. Warranty equipment to be 2 years for material and labor after Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Cleaver-Brooks.

2. Stickle Steam Specialties.

3. Superior.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Deaerator shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the deaerator will remain in place without separation of any parts when subjected to the seismic forces specified and the deaerator will be fully operational after the seismic event."
2. Component Importance Factor: 1.5
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

B. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state. This shall occur immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a

backup power source or through normal power if restored before backup power is brought on-line.

2. See Drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. ASME Compliance: Fabricate and label deaerator and components to comply with ASME Boiler and Pressure Vessel Code.

2.3 MANUFACTURED UNITS

A. Tray-type, two-stage deaerator package with boiler feedwater pumps and controls to supply boiler feedwater to boilers; and two separate packaged condensate receiver with transfer pumps and controls to supply feedwater to deaerator.

B. Material for Wetted Components: Deaerator components in contact with water that has not been deaerated shall be made of Type 304 or 316 stainless steel as specified herein.

C. Spring-loaded Pressure-compensating Adjustable Spray Valves: Type 316 stainless steel. Arrange spray valves and vent condenser for counterflow of steam and condensate; and so corrosive gases being vented do not contact deaerator's head or shell.

D. Vent Condenser: Type 304 stainless steel, not thinner than 12-gauge, with automatic and manual vent valves for evacuation of non-condensable gases.

E. Trays: Tray sections shall be fabricated of Type 316L stainless steel not thinner than 16-gauge; riveted construction. Each tray section shall be removable and replaceable by one person via a davited vessel manway.

F. Deaerator and Storage Pressure Vessel(s):

1. Material: ASTM 516 Grade 70 carbon steel. Pressure vessel shall be designed, constructed, inspected and stamped for 30 psig @ 450 deg F in accordance with ASME Section VIII, Division 1.

2. Access: Manway in deaerator and storage tank for access to internal components for inspection and service.

   a. Manway cover shall be davited.

3. Pump suction outlets to incorporate vortex breakers welded to vessel.

4. Factory-Installed Pipe, NPS 2-1/2 and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 80; with threaded joints and fittings.

    a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150.
    b. Malleable-Iron Unions: ASME B16.39, Class 150.

5. Factory-Installed Pipe, NPS 3 and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 80; with welded joints and carbon-steel fittings and flanges.

    a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
    b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and gaskets.

G. Accessories:

1. Insulation rings suitable for 2-inch thick insulation.
2. Lifting eyes.
3. Connections ≤ 2 inches: NPT threads; > 2 inches: Class 150 lb. raised face flanges.
4. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
5. Pump discharge piping manifold for single connection to boiler feedwater pipe shall include with check valves, isolation valves, and liquid-filled pressure gauge graduated in pounds force per square inch, gauge.
6. Pump-discharge recirculation orifice plate sized to provide minimum required flow for continuous pump operation with boiler feedwater valves at boilers closed.
7. Feedwater Inlet Assembly:
    a. Factory-fitted. field-mounted, electric modulating valve. with three-valve bypass, with factory-mounted water-level controller.

        1) Level controller shall feature proportional/integral/derivative operation and tuning.
        2) Level controller shall be electrically powered and operated.
        3) Level controller shall be external cage, displacer type.
        4) External cage shall have threaded connections to water column piping of same size connected to the top and bottom of the storage vessel.
        5) Water column piping shall incorporate isolation valves for removal of level controller without draining the storage vessel. Water column piping drain leg with shutoff valve shall also be included.
    b. Factory-mounted, three-valve bypass and inlet strainer.

8. Steam Pressure-Reducing Valve: Electrically powered and operated modulating valve. with three-valve bypass, and selected and sized to reduce boiler operating pressure to the deaerator operating pressure.

a. Steam pressure reducing valve shall be mounted not greater than 50 pipe diameters from deaerating section of deaerator assembly.
b. Steam pressure reducing valve shall be controlled by an electrically powered and operated pressure controller.

1) Pressure controller shall feature proportional/integral/derivative operation and tuning.
2) Pressure control unit shall be remotely mounted adjacent to the deaerator electrical panel and legible and accessible from operating floor without ladders, catwalks, lifts or scaffolding.
3) Pressure sensing line for steam pressure controller shall be connected directly to the deaerating section of deaerator assembly.

9. Tank Overflow Drainer: Self-contained overflow trap sized to relieve not less than 120% of deaerator design capacity at deaerator operating pressure, with steel housing and stainless-steel float ball. Connection on deaerator shall be same size as overflow drainer.
10. Safety Valve(s): ASME labeled and sized to relieve full capacity of steam pressure-reducing valve at deaerator vessel design pressure. Provide each safety valve with a drip-pan elbow.
11. Vents: Manual and automatic vent valves.

a. Automatic air vents shall be thermostatically self-controlled to provide a fast means of venting when a sudden buildup of gas occurs.
b. Manual air vents shall have an orifice to provide continuous venting at a rate of up to 0.1 percent of rated deaerator capacity at operating pressure indicated.

12. High-temperature condensate diffuser tube.
13. Vacuum breaker.
14. Instruments and Gauges:

a. Full-height, water-level gauge glass with gauge rods to protect glass and stop valve set, ball check and shutoff cocks, water-column blowdown valves, and vacuum breaker.
b. Thermometer:

1) Bimetal dial-type thermometer graduated in Fahrenheit mounted to measure temperature in storage and steam section of tank.
2) Graduated scale with a range of 50-300 deg F.
3) Any angle position adjustment. Stainless-steel case with nominal 5-inch- dial face.
4) Mount thermometer in a Type 316 stainless-steel thermowell.

c. Pressure Gauge:

1) Pressure gauge graduated in pounds force per square inch gauge mounted to measure pressure in steam section of tank and pressure at feedwater discharge manifold pipe.

2) Nominal 4-1/2-inch-diainstrument face with graduated scale and siphon with isolation valve. Gauge shall have normal operating pressure approximately 50 percent of full range and an accuracy of 1 percent.

d. Instruments and gauges shall be easily readable by operator standing at grade adjacent to unit. Provide remote reading gauges if required to comply with requirement.

15. Provision for chemical injection quill.
16. Sample Cooler: Factory installed or furnished for field installation, with needle valve for each connection. Constructed of Type 316 stainless steel.
17. Tank drain connection with valve.
18. Oxygen test kit.
19. Elevating Stand: Structural steel elevating stand for supporting tank and pumps. Bolt to tank supports.

    a. Elevating stand shall be fabricated from A36 structural steel utilizing AISI standard structural shapes.
    b. Elevating stand shall be of welded construction conforming to AWS standards.
    c. Fabricate elevating stand with bracing and gussets as necessary to meet the requirements for combined dead and live loads when deaerator is completely full for seismic forces according to authorities having jurisdiction for the jobsite location.
    d. Design deaerator and elevating stand assembly for installation by anchoring deaerator and stand assembly to floor only.
    e. Minimum height of elevating stand shall be as required by application, including providing a height not less than 120% of the NPSH requirement of the boiler feed pumps at pump design flow. This minimum height shall be calculated by subtracting the head loss due to friction in the pump suction piping assembly at pump design flow from the vertical distance between the bottom of the deaerator storage vessel and the centerline of the pump suction connection.

H. Feedwater Pump: Cast-iron, base-mounted volute; with stainless-steel, multistage centrifugal impeller, renewable bronze case ring, and stainless-steel shaft.

1. Seals: Mechanical, suitable for 250 deg F.
2. Pump Motor: Vertical, close or flexibly coupled to pump. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:

    a. Efficiency: Premium efficient.
    b. Enclosure: totally enclosed fan cooled.
    c. Insulation Class: F
    d. Service Factor: 1.15.
    e. Motors operated through variable-frequency controllers shall be inverter duty rated per NEMA MG-1, Section IV, "Performance Standard Applying

to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."

3. Motor Sizes: Minimum size as indicated; non-overloading throughout the pump curve and without requiring motor to operate in service factor at any point.

2.4 CONDENSATE RECEIVER ASSEMBLY

A. Description: Factory-assembled and -tested unit consisting of a condensate receiver, transfer pumps, and controls.

B. Accessories:
1. Makeup Water Inlet Assembly:
   a. Factory-fitted. field-mounted, electric modulating valve. with three-valve bypass, with factory-mounted water-level controller.
      1) Level controller shall feature proportional/integral/derivative operation and tuning.
      2) Level controller shall be electrically powered and operated.
      3) Level controller shall be external cage, displacer type.
      4) External cage shall have threaded connections to water column piping of same size connected to the top and bottom of the storage vessel.
      5) Water column piping shall incorporate isolation valves for removal of level controller without draining the storage vessel. Water column piping drain leg with shutoff valve shall also be included.
   b. Factory-mounted, three-valve bypass and inlet strainer.

2. Thermometer:
   a. Bimetal dial-type thermometer graduated in Fahrenheit.
   b. Graduated scale with a range of approximately 1.5 times the normal operating temperature.
   c. Any angle position adjustment.
   d. Stainless-steel case with nominal 5-inch-diainstrument face.
   e. Mount thermometer in a Type 316 stainless-steel thermowell.

3. Full-height, water-level gauge glass with gauge rods to protect glass and stop valve set, ball check and shutoff cocks, water-column blowdown valves, and vacuum breaker.
4. Lifting eyes.
5. Connections ≤ 2 inches: NPT threads; > 2 inches: Class 150 lb. raised face flanges.
6. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
7. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gauge graduated in pounds force per square inch, gauge. Gauge with nominal 4-inch-diainstrument face, isolation valve, normal operating pressure about 50 percent of full range, and an accuracy of 1 percent.

8. Gauges shall be easily readable by operator standing at grade adjacent to unit. Provide remote reading gauges if required to comply with requirement.
9. Pump-discharge bypass orifice plate sized to provide continuous pump operation.

C. Factory-Installed Pipe, NPS 2-1/2 and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 80; with threaded joints and fittings.

1. Cast-Iron Threaded Fittings: ASME B16.4, Class 125.
2. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150.
3. Malleable-Iron Unions: ASME B16.39, Class 150.

D. Factory-Installed Pipe, NPS 3 and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 80; with welded joints and carbon-steel fittings and flanges.

1. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
2. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and gaskets.

E. Storage Vessel:

1. Material: Welded carbon steel ASTM 516 Grade 70.

2. Condensate receiver vessel interior surface shall be completely coated with a water-resistant, abrasion-resistant phenolic epoxy coating polymerized with a polyamine type curing agent.

    a. Coating designed for operation up to 250 deg F.
    b. Application of coating shall be in accordance coating manufacturer’s instructions including surface preparation, coating thickness and curing.

3. Access: 12x16 manway in tank for access to internal components for inspection and service.

4. Pump suction outlets to incorporate vortex breakers welded to vessel.

5. Insulation rings suitable for 2-inch-thick insulation.

6. Elevating Stand: Structural-steel elevating stand for supporting tank and pumps. Bolt to tank.

    a. Elevating stand shall be fabricated from A36 structural steel utilizing AISI standard structural shapes.
    b. Elevating stand shall be of welded construction conforming to AWS standards.
    c. Fabricate elevating stand with bracing and gussetts as necessary to meet the requirements for combined dead and live loads when receiver is

completely full for seismic forces according to authorities having jurisdiction for the jobsite location.

d. Design condensate receiver and elevating stand assembly for installation by anchoring receiver and stand assembly to floor only.

e. Minimum height of frame shall be as required by application, including providing a height not less than 120% of the NPSH requirement of the boiler feed pumps at pump design flow. This minimum height shall be calculated by subtracting the head loss due to friction in the pump suction piping assembly at pump design flow from the vertical distance between the bottom of the condensate receiver vessel and the centerline of the pump suction connection.

F. Transfer Pumps: Vertical, flange-mounted, close-coupled, or multistage, radially split-case centrifugal pump; rated for 250-psig minimum working pressure and a continuous water temperature of 225 deg F; with the following features:

1. Impeller: Stainless steel.
2. Seals: Mechanical.

G. Transfer Pump Motor: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:

1. Efficiency: Premium efficient.
2. Enclosure: totally enclosed fan cooled.
3. Insulation Class: F
4. Service Factor: 1.15.
5. Motors operated through variable-frequency controllers shall be inverter duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
6. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.5 DEAERATOR AND CONDENSATE RECEIVER CONTROLS AND PARAMETERS

A. Factory-installed and -wired controllers, instruments, sensors, switches, transformers, transmitters, valves, and other control devices necessary to provide a complete and functioning unit to operate as indicated and connect to field control interfaces indicated.

B. Operating controls shall include the following devices and features:

1. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
2. Set-Point Adjust: Operating and alarm set points shall be field adjustable.

C. Control Enclosures:

1. NEMA 250, Type 12.

a. Provide enclosure with integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.

2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
3. Mounted on deaerator assembly at a location convenient to operator.
4. Provide hinged full-size door with key lock. Provide common key for all locks.
5. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls; other section shall house line voltage controls.
6. Enclosure shall house the following:

   a. Control transformers with fuses.
   b. Labeled terminal strips.
   c. Microprocessor-based controller(s) to provide control and alarm functions indicated.
   d. Audible indication of safety alarms.
   e. Dry Contacts:

      1) For interface with chemical feed pump controls.

7. Face of enclosure shall provide the following:

   a. Visual indication of operating components and alarms with momentary test push button.
   b. Visual indication of elapsed run time, graduated in hours.
   c. Auto/local capability to allow operator to manual operate unit locally.
   d. Audible alarm silence capability.
   e. Labels for switches, lights, and displays to provide clear indication of service.

8. For units with condensate receiver assembly mounted on a separate elevating stand from the deaerator assembly, provide a separate control panel for deaerator and condensate receiver assemblies.

D. Control Instrument Enclosures: Control instruments and devices that are mounted on the package assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.

E. Control Cable and Wire:

1. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
2. Install cable and wiring located outside of enclosure(s) in a metal raceway.
3. Use flexible conduit to make final terminations.
4. Provide watertight installation for applications exposed to moisture.

F. Touch-Screen Local Operator Interface: Provide local operator interface through a touch-screen graphical color display for setup, monitoring, and data acquisition.

1. Monitoring:

    a. Pump operating status (on/off).
    b. Pump lead/lag status (lead/lag position).
    c. Pump speed for variable-speed pumps (analog value, zero to 100 percent).
    d. Pump operation failure alarm.
    e. Pump starts.
    f. Pump run time.
    g. Pump manifold pipe discharge flow rate (analog valve).
    h. Pump manifold pipe discharge pressure (analog valve, gauge pressure).
    i. Steam pressure (analog value, gauge pressure).
    j. Steam valve open position (analog value, zero to 100 percent).
    k. Tank water level (analog value).
    l. Tank high-water-level alarm (analog value).
    m. Tank low-water-level alarm (analog value).
    n. Tank low-water-level cutoff alarm (digital value).
    o. Makeup water valve open position (analog value, zero to 100 percent).
    p. Tank temperature (analog value).

2. Control Setup:

    a. Pump operation (on/off).
    b. Pump lead/lag operation (lead/lag position).
    c. Pump speed for variable-speed pumps (analog value, zero to 100 percent).
    d. Pump manifold pipe discharge pressure set point (analog valve, gauge pressure).
    e. Steam pressure set point (analog value, gauge pressure).
    f. Steam pressure control valve open position override (analog value, zero to 100 percent).
    g. Tank water level set point (analog value).
    h. Tank high-water-level alarm set point (analog value).
    i. Tank low-water-level alarm set point (analog value).
    j. Tank low-water-level cutoff alarm set point (digital value).
    k. Makeup water valve open position override (analog value, zero to 100 percent).

G. DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display deaerator and condensate receiver status and alarms.

1. Communication Interface: ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control and monitor deaerator operation from an operator workstation. Control features available, and monitoring points displayed, locally at deaerator control panel shall be available to control system through the interface.

H. Makeup Water and Feedwater Control Sequence:

1. For normal operating mode, condensate receiver makeup shall be directed to the active condensate receiver system. The deaerator will receive all feedwater from active condensate receiver system only.

a. In accordance with the steam P&ID, valving shall be installed so that feedwater may be redirected to other points in the feedwater train to maintain temporary system operability in the event of a shutdown of various equipment in the train.

2. Electric proportional level controllers operates electric modulating control valves to constantly maintain tank water-level set point for deaerator and condensate receivers.
3. Visual alarm indication of low and high tank water level.
4. Low-water level stops pumps.
5. Visual indication of makeup water flow rate.

I. Boiler Feedwater Pump Continuous Control Sequence:

1. Pump runs continuously while boiler operates. Electric interlock with boiler control to start lead pump when boiler starts.
2. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
3. Lead and lag pumps alternate to equalize run time.
4. Lead pump failure automatically starts lag pump.
5. Feedwater pressure controller controls operating feedwater pump(s) speed and starts and stops lag pump(s) to maintain feedwater pressure set point.
6. Visual indication of pump status.
7. Visual indication of pump starts.
8. Visual indication of pump run time.
9. Visual indication of pump lead/lag status.
10. Visual alarm indication of pump failure.
11. Visual indication of feedwater flow rate.

J. Transfer Pump Continuous-Run Control Sequence:

1. Lead pump runs continuously while deaerator is operating; deaerator water-level controller modulates water-level-control valve; lead and lag pump(s) switch to equalize run time; lag pump operates if lead pump fails; pump failure sounds alarm.

2.6 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to unit.

1. For units with condensate receiver assembly mounted on a separate support frame from deaerator assembly, provide a separate field electrical connection for deaerator and condensate receiver assemblies.
2. Enclosure: NEMA 250, Type 12.

a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
b. Mounted on deaerator assembly at a location convenient to operator.
c. Enclosure shall have hinged full-size door with key lock with common key for all locks.

3. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
4. Install wiring outside of an enclosure in a metal raceway. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
5. Field power interface shall be to fused disconnect switch. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
6. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
7. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

   a. Alternating control as indicated by control sequence for each pump.

8. Provide transformer with fuses and power wiring to power a 20-A, 120-V duplex receptacle mounted in each control panel for use in connecting analytical and testing equipment.

2.7 FACTORY FINISHES

A. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.

B. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.

2.8 CAPACITIES AND CHARACTERISTICS

A. Nominal Capacity: 45,000 lb/hr

B. Design Feedwater Flow Rate: 105 gpm .

C. Steam Flow Rate: 45,000 lb/hr

D. Steam Condensate Flow Rate: 45 gpm

E. Steam Condensate Temperature: 180 deg F

F. Makeup Water Flow Rate: 45 gpm

G. Makeup Water Temperature: 60 deg F

H. Deaerator Capacity: Capable of raising temperature of condensate and makeup water to within 3 deg F of saturated steam temperature corresponding to deaerator operating pressure.

I. Minimum Deaerator Vessel Design Pressure: 30 psig.

J. Operating Pressure Range: 2-15 psig.

K. Resultant Oxygen Content: Not more than 0.005 cc/L through an operating range between 5 and 100 percent of full load.

L. Storage Tank:

1. Tank Capacity to Overflow: 1,100 gallons .
2. Storage Time: 10 minutes.

M. Boiler Feedwater Pumps:

1. No. of Pumps: four (4) .
2. Design Flow Rate: 75 gpm
3. Minimum Flow Rate: 18 gpm
4. NPSHR: (supplier to provide)
5. Rated Operating Temperature: 250 deg F
6. Discharge Head: 440 ft
7. Maximum Close-off Head: 575 ft
8. Horsepower: 15 HP
9. Speed: 3,500 rpm

N. Condensate Receiver: (Two Required)

1. Tank Capacity to Overflow: 1,200 gallons
2. Storage Time: 10 minutes each.

O. Transfer Pumps:

1. No. of Pumps: Duplex.
2. Design Flow Rate: 150 gpm
3. Minimum Flow Rate: 35 gpm
4. NPSHR: (supplier to provide)
5. Rated Operating Temperature: 215 **deg F**.
6. Discharge Head: 110 ft
7. Horsepower: 10
8. Speed: 3,500

P. Deaerator Assembly Single-Point Power Electrical Characteristics:

1. Volts: 460 V.
2. Phase: Three.

3. Hertz: 60.
4. Full-Load Amperes: (supplier to provide)
5. Minimum Circuit Ampacity: (supplier to provide)
6. Maximum Overcurrent Protection: (supplier to provide)

Q. Condensate Receiver Assembly Single-Point Power Electrical Characteristics:

1. Volts: 460 V.
2. Phase: Three.
3. Hertz: 60.
4. Full-Load Amperes: (supplier to provide)
5. Minimum Circuit Ampacity: (supplier to provide)
6. Maximum Overcurrent Protection: (supplier to provide)

2.9 SOURCE QUALITY CONTROL

A. Fabricate and label deaerator vessel according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

B. Factory install and test piping that connects pumps to tanks according to ASME B31.1, "Power Piping.".

C. Factory Tests: Test performance and submit test results on packaged deaerator units, according to ASME PTC 12.3.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting deaerator performance, maintenance, and operations.

1. Deaerator locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping to verify actual locations of piping connections before installation of deaerator.

C. Examine areas for suitable conditions where deaerator will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Maximum allowable height of any completed assembly package: 23 feet.

C. Equipment Mounting:

1. Install deaerator on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Install deaerator to permit access for service and maintenance.

E. Where installing piping adjacent to machine, allow space for service and maintenance.

F. Support piping independent of equipment.

G. Install base-mounted pumps on concrete base with grouted base frame.

H. Install all parts and materials not factory installed.

I. Assemble and install deaerator and condensate receivers trim, components, and accessories that are not factory installed.

J. Install control and electrical devices furnished with deaerator and condensate receivers that are not factory mounted.

K. Install control and power wiring to field-mounted control and electrical devices furnished with deaerator and condensate receivers that are not factory installed.

L. Perform cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Following cleaning procedures, deaerator shall be washed and flushed until water leaving deaerator is clear.

M. Protect deaerator package and condensate receiver packages from corrosion.

1. Before filling with water, protect by dry storage method recommended by manufacturer.
2. After filled with water, protect by wet storage method recommended by manufacturer.

N. Chemical Treatment: Quality of water in deaerator shall be maintained by a professional water treatment organization that shall provide on-site supervision to maintain the required water quality during periods of storage, operating, standby, and test conditions. See applicable water treatment Section.

3.3 PIPING CONNECTIONS

A. Steam and condensate piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect steam and condensate piping to vessel tappings with shutoff valves and unions or flanges at each connection.

C. Connect condensate drains, pump-discharge piping, vents, overflow drains, makeup water, steam supply, and cooling water piping.

1. Extend overflow drains to floor drains.
2. Extend vent piping to outside and terminate with manufacturer-approved cap furnished with deaerator.
3. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.
4. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.

1. Provide a temperature-controlled, non-potable, domestic cold water source to cool hot equipment drains to deliver a discharge temperature of 120 deg F

E. Connect chemical treatment piping to each deaerator chemical treatment connection with check valve and isolation valve.

F. Where installing piping adjacent to deaerator, allow space for service and maintenance.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between deaerator and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between deaerator control interface and DDC system for remote monitoring and control of deaerator. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engauge a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engauge a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Verify bearing lubrication.
4. Verify proper motor rotation.
5. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Deaerator will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engauge a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Set makeup water-level controls.
3. Set operating controls.
4. Verify safety controls.
5. Verify lubrication.
6. Verify proper motor rotation.
7. Start pumps according to manufacturer's written instructions.

B. Report: Prepare a written report to record the following:

1. Procedures used.

2. Initial findings.
3. Final results.
4. Corrective action taken to achieve compliance with requirements indicated.
5. Date of testing.
6. Name and contact information for person performing testing.

3.8 ADJUSTING AND CLEANING

A. Adjust initial temperature and pressure set points.

B. Set field-adjustable switches and circuit-breaker trip ranges.

C. Clean strainers.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain deaerator.

B. Video training sessions, and provide electronic copy of video to Owner.

END OF SECTION 235316

SECTION 235405 - CONTINUOUS BLOWDOWN HEAT RECOVERY SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged, factory-assembled continuous blowdown heat recovery system.

1.3 DEFINITIONS

A. DDC: Direct digital control.

1.4 ACTION SUBMITTALS

A. Product Data: For each unit to include the following:

1. Equipment performance and operating characteristics, such as rated feedwater makeup water, continuous blowdown mass flow rate; boiler operating pressure; continuous blowdown heat recovery system operating pressure; continuous blowdown flash tank size and orientation.
2. Furnished specialties and accessories.
3. Construction details, material descriptions, dimensions and weight of individual components and profiles and finishes.
4. Force and moment capacity of each field piping connection.
5. Dimensioned location of low and high and normal water level showing operating set point and each alarm set point.
6. Temperature and pressure rating, size, and materials of construction for trim components including, piping, fittings, flanges, unions, and valves. Provide valve manufacturer Product Data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.
7. Manufacturer Product Data showing size, scale range, and accuracy of thermometers and pressure gages.
8. Detailed information of controls including Product Data with technical performance, operating characteristics, and sequence of operation.
9. Product Data for shell and tube heat exchanger, including design heat transfer rate. and materials of construction.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring, if any. Differentiate between factory and field installation.
4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For continuous blowdown heat recovery system, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Startup service reports.

D. ASME Stamp Certification and Report: Submit "U" or "UM" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of pressure vessels of the continuous blowdown heat recovery system.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For continuous blowdown heat recovery system, components, and accessories to include in emergency, operation, and maintenance manuals.

B. Spare Parts List: Recommended spare parts list with quantity for each.

C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Gaskets: Furnish one replacement gasket(s) for each gasketed opening.
2. Gage Glass: Furnish one replacement glass(es) for each gage glass..

B. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Ship continuous blowdown heat recovery system from the factory free of water. Drain water and blow continuous blowdown heat recovery system dry with compressed air if required to remove all water before shipping.

B. Cover and protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping, storage, and handling.

C. Cover and protect electrical and control devices and open connections.

D. Comply with manufacturer's written rigging instructions.

E. Deliver continuous blowdown heat recovery system as factory-assembled units with protective crating and covering. Continuous blowdown heat recovery system vessel and assembly to be separated for shipment and reassembly in field. Connections of all components and equipment disassembled for shipment shall be match-marked at factory prior to disassembly for ease of reassembly in field.

F. Protect continuous blowdown heat recovery system components with removable temporary enclosures to prevent damage during shipping, storage, and installation.

1.9 Warranty

A. Warranty equipment to be 2 years for material and labor after Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Stickle Steam Specialties
2. Wilson Engineering
3. Cleaver-Brooks.
4. Superior.
5. Madden Engineering Products.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Continuous blowdown heat recovery system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the continuous blowdown heat recovery system will remain in place without separation of any parts when subjected to the seismic forces specified and the continuous blowdown heat recovery system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

B. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state. This shall occur immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source or through normal power if restored before backup power is brought on-line.
2. See Drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. ASME Compliance: Fabricate and label continuous blowdown heat recovery system and components to comply with ASME Section VIII, Division 1 Boiler and Pressure Vessel Code.

2.3 MANUFACTURED UNITS

A. Continuous blowdown heat recovery shall be of the two-stage design.

1. First stage shall consist of a continuous blowdown flash tank with the following features.

a. The vessel design shall be vertically oriented with diameter sized to permit flash steam from continuous blowdown influent to move upward with a vertical velocity of no greater than 4 feet per second at design operating flow and pressure.
b. Tangential Inlet.

1) Continuous blowdown horizontal inlet shall be incorporated on a tangent to the vertical axis of the vessel. The inlet shall be positioned in the upper one-third of the vertical shell of the vessel.
2) An erosion wear ring shall be continuous-welded to the vessel interior at the same elevation as the inlet.

a) Width of the wear ring shall not be less than three times the inlet diameter.
b) Wear ring shall be complete cylinder.
c) Wear ring shall be fabricated of same grade of carbon steel as the pressure vessel.

2. Second stage shall consist of a shell and tube heat exchanger.

a. Size of heat exchanger shall be standard model from manufacturer.
b. U-tube bundle shall be fabricated using AISI 304 stainless steel tubes and tube sheets.
c. Shell shall be constructed of carbon steel of manufacturer's standard material.

3. Heat exchanger shall be oriented horizontally and positioned at an elevation lower than the bottom of the continuous blowdown flash tank.
4. Blowdown condensate shall drain from flash tank to shell side of heat exchanger.

a. Heat exchanger shell shall be rotated so that the shell inlet is on the bottom and the shell outlet is on the top.

5. Flash tank and heat exchanger shall be mounted with anchor bolts on a common base fabricated using A36 structural members with welded construction.

a. Base shall incorporate a minimum of four anchor bolt holes around perimeter of the base for anchoring to concrete pad beneath the base.

B. Accessories:

1. Insulation rings suitable for 2-inch thick insulation.
2. Lifting eyes.
3. Companion flanges.

a. Blowdown Condensate Level Control. Factory-fitted, field-mounted, modulating level control valve with factory-mounted water-level controller.

1) Level control valve shall be positioned in the piping at outlet of heat exchanger shell.

a) Level control valve shall be electrically powered and operated.

b) Elevation of level control valve including piping between heat exchanger shell and valve shall be below bottom of the flash tank.

2) Level controller shall feature proportional operation and tuning.
3) Level controller shall be electrically powered and operated.
4) Level controller shall be external cage, float or displacer type.
5) External cage shall have threaded connections to water column piping of same size connected to the top and bottom of the storage vessel.
6) Water column piping shall incorporate isolation valves for removal of level controller without draining the storage vessel. Water column piping drain leg with shutoff valve shall also be included.

b. Factory-mounted, three-valve bypass and inlet strainer around level control valve.
c. System shall include piping for bypassing the heat exchanger on both tube side and shell side for heat exchanger maintenance. Piping shall be configured so that the tube bundle can be removed without interference with the bypass piping.

4. Continuous Blowdown Flow Control Valves: Class 800 lb forged steel globe-style manual flow control valve, threaded connections.

a. One dedicated control valve for each boiler.
b. 1/2-inch NPT body
c. A105 carbon steel
d. Round Bolted Bonnet
e. Spiral Wound Gasket
f. Outside Screw & Yoke
g. Bolted Gland
h. Loose V-Port Disc
i. Integral Hard Faced Seat
j. Dial & Indicator
k. ASME B16.34
l. All continuous blowdown flow control valves shall be connected to a common piping manifold.

1) The manifold size shall be not less than 4-inch pipe size.
2) Manifold pipe shall be fabricated of A106 seamless carbon steel pipe, Schedule 80.
3) The valves shall be arranged inline on the manifold.
4) The manifold shall be directly connected to the inlet of the continuous blowdown flash tank.

a) Size of flash tank inlet shall be equal to the manifold pipe size.
b) Connection shall be 150 lb flange.

5) The manifold connection for each valve shall be fabricated utilizing 3000 lb full coupling, steel. Each coupling is to be welded into the manifold at a 45-deg angle in line with the manifold centerline. Distance between these connections shall be sufficient to allow installation, operation and maintenance of the flow control valves.

a) Each control valve shall be connected to the coupling by a nipple of sufficient length to allow installation, operation and maintenance of the valve. Nipple shall be A106 seamless carbon steel pipe, Schedule 80.
b) Coupling and nipple shall be the same size as the control valve body.

6) Distance between the manifold connection to the flash tank and the closest blowdown flow control valve connection on the manifold shall not be less than 12 inches nor greater than 24 inches.
7) The overall length of the manifold shall be no greater than what is necessary to meet the spacing requirements specified in this section.

5. Safety Valve(s): ASME labeled and sized to relieve full capacity of flash steam at continuous blowdown heat recovery system vessel design and flow pressure. Provide each safety valve with a drip-pan elbow.
6. Meters and Gauges:

a. Full-height, water-level gage glass with gage rods to protect glass and stop valve set, ball check and shutoff cocks, water-column blowdown valves, and vacuum breaker.
b. Thermometer:

1) Bimetal dial-type thermometer graduated in Fahrenheit mounted to measure temperature in storage and steam section of tank.
2) Graduated scale with a range of 50-300 deg F.
3) Any angle position adjustment.
4) Stainless-steel case with nominal 5-inch- diameter face.
5) Mount thermometer in a Type 316 stainless-steel thermowell.

c. Pressure Gage:

1) Pressure gage graduated in pounds force per square inch gauge mounted to measure pressure in steam section of tank and pressure at feedwater discharge manifold pipe.
2) Nominal 4-1/2-inch-diameter face with graduated scale and siphon with isolation valve. Gage shall have normal operating pressure approximately 50 percent of full range and an accuracy of 1 percent.

d. Meters and gages shall be easily readable by operator standing at grade adjacent to unit. Provide remote reading gages if required to comply with requirement.
e. Fabricate base with bracing and gussetts as necessary to meet the requirements for combined dead and live loads when continuous blowdown heat recovery system is completely full for seismic forces according to authorities having jurisdiction for the jobsite location.
f. Design continuous blowdown heat recovery system and elevating stand assembly for installation by anchoring continuous blowdown heat recovery system and stand assembly to floor only.

2.4 FACTORY FINISHES

A. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.
B. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.

2.5 CAPACITIES AND CHARACTERISTICS

A. Nominal Continuous Blowdown Flow Rate: 2,250 lbs/hr
B. Boiler Operating Pressure: 125 psig
C. Continuous Blowdown Flash Tank Operating Pressure: 5 psig
D. Makeup Water Flow Rate: 45 gpm
E. Makeup Water Temperature: 60 deg F
F. Heat Exchanger Approach Temperature: ≤ 5 deg F

2.6 SOURCE QUALITY CONTROL

A. Fabricate and label continuous blowdown heat recovery system pressure vessels according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1. Continuous Blowdown Flash Tank: 30 psig @ 300 deg F
2. Heat Exchanger: 150 psig @ 450 deg F.

B. Factory install and test piping that connects boilers to continuous blowdown flash tanks according to ASME B31.1, "Power Piping.".

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting continuous blowdown heat recovery system performance, maintenance, and operations.

1. Continuous blowdown heat recovery system locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping to verify actual locations of piping connections before installation of continuous blowdown heat recovery system.
C. Examine areas for suitable conditions where continuous blowdown heat recovery system will be installed.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
B. Equipment Mounting:

1. Install continuous blowdown heat recovery system on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Install continuous blowdown heat recovery system to permit access for service and maintenance.
D. Where installing piping adjacent to machine, allow space for service and maintenance.
E. Support piping independent of equipment.
F. Install base-mounted pumps on concrete base with grouted base frame.
G. Install all parts and materials not factory installed.
H. Assemble and install continuous blowdown heat recovery system trim, components, and accessories that are not factory installed.
I. Perform cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Following cleaning procedures, continuous blowdown heat recovery system shall be washed and flushed until water leaving continuous blowdown heat recovery system is clear.
J. Protect continuous blowdown heat recovery system from corrosion.

1. Before filling with water, protect by dry storage method recommended by manufacturer.
2. After filled with water, protect by wet storage method recommended by manufacturer.

3.3 PIPING CONNECTIONS

A. Steam and condensate piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Connect steam, feedwater makeup and continuous blowdown piping to vessel tappings with shutoff valves and unions or flanges at each connection.
C. Connect vessel drains, vents, makeup water, steam outlet, and continuous blowdown outlet water piping.

1. Extend drains to floor drains.
2. Extend steam outlet piping from continuous blowdown flash tank to steam inlet piping to deaerator downstream of deaerator pressure control valve.
3. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.
4. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.

1. Provide a temperature-controlled, non-potable, domestic cold water source to cool hot equipment drains to deliver a discharge temperature of 140 deg F

E. Connect chemical treatment piping to each continuous blowdown heat recovery system chemical treatment connection with check valve and isolation valve.

F. Where installing piping adjacent to continuous blowdown heat recovery system, allow space for service and maintenance.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between continuous blowdown heat recovery system control interface and DDC system for remote monitoring and control of system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Set operating controls.
3. Verify safety controls.

B. Report: Prepare a written report to record the following:

1. Procedures used.
2. Initial findings.
3. Final results.
4. Corrective action taken to achieve compliance with requirements indicated.
5. Name and contact information for person performing testing.

3.8 ADJUSTING AND CLEANING

A. Adjust initial temperature and pressure set points.
B. Clean strainers.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain continuous blowdown heat recovery system.

END OF SECTION 235405

SECTION 235410 – INTERMITTENT BLOWDOWN SEPARATOR SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged, factory-assembled intermittent blowdown separator system.

1.3 ACTION SUBMITTALS

A. Product Data: For each unit to include the following:

1. Equipment performance and operating characteristics, such as maximum boiler pressure, inlet connection size, steam vent connection size, blowdown condensate outlet connection size and cooling water inlet connection size.
2. Furnished specialties and accessories.
3. Construction details, material descriptions, dimensions and weight of individual components, and profiles and finishes.
4. Force and moment capacity of each field piping connection.
5. Temperature and pressure rating, size, and materials of construction for trim components including, piping, fittings, flanges, unions, and valves. Provide valve manufacturer Product Data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.
6. Manufacturer Product Data showing size, scale range, and accuracy of thermometers.
7. Detailed information of controls including Product Data with technical performance, operating characteristics, and sequence of operation.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Differentiate between factory and field installation.
4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For intermittent blowdown separator system, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Startup service reports.

D. ASME Stamp Certification and Report: Submit "U" or "UM" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of pressure vessels of the intermittent blowdown separator system.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For intermittent blowdown separator system, components, and accessories to include in emergency, operation, and maintenance manuals.

B. Spare Parts List: Recommended spare parts list with quantity for each.

C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Gaskets: Furnish one replacement gasket(s) for each gasketed opening.

B. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Ship intermittent blowdown separator system from the factory free of water. Drain water and blow intermittent blowdown separator system dry with compressed air if required to remove all water before shipping.

B. Cover and protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping, storage, and handling.

C. Cover and protect electrical and control devices and open connections.

D. Comply with manufacturer's written rigging instructions.

E. Deliver intermittent blowdown separator system as factory-assembled unit with protective crating and covering. Intermittent blowdown separator system vessel and assembly to be separated for shipment and reassembly in field. Connections of all components and equipment disassembled for shipment shall be match-marked at factory prior to disassembly for ease of reassembly in field.

F. Protect intermittent blowdown separator system components with removable temporary enclosures to prevent damage during shipping, storage, and installation.

1.8 Warranty

A. Warranty equipment to be 2 years for material and labor after Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Cleaver-Brooks.

2. Stickle Steam Specialties.

3. Superior

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Intermittent blowdown separator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the intermittent blowdown separator system will remain in place without separation of any parts when subjected to the seismic forces specified and the intermittent blowdown separator system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5
3. Component Amplification Factor =1.0

4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

B. ASME Compliance: Fabricate and label intermittent blowdown separator system and components to comply with ASME Section VIII, Division 1 Boiler and Pressure Vessel Code.

2.3 MANUFACTURED UNITS

A. Intermittent blowdown separator system shall consist of the following components.
1. Blowdown separator vessel.
    a. Vertically oriented vessel to be designed, constructed, inspected and stamped for 30 psig at 375 deg F.
2. Blowdown separator aftercooler.
    a. Aftercooler to be designed and fabricated to temper intermittent blowdown condensate by introducing cold water from external source.
3. Automatic temperature control valve.
    a. Control valve to be self-contained cold water tempering valve with temperature sensing bulb for insertion into separator outlet aftercooler.
4. Temperature indicator with thermowell located on aftercooler downstream of tempering water inlet.
5. Intermittent blowdown vessel support legs shall be fabricated using A36 structural members with welded construction.
    a. Legs shall incorporate anchor bolt holes for anchoring to concrete pad beneath the system.
    b. Legs shall provide sufficient height for attaching piping two consecutive long radius elbows, both in vertical orientation, to aftercooler outlet, of same size as aftercooler connection.

B. Accessories:

1. Insulation rings suitable for 2-inch thick insulation.
2. Lifting eyes.
3. Companion flanges.
4. Factory-mounted, three-valve bypass and inlet strainer around temperature control valve.
5. “”Meters and Gauges:
    a. Thermometer:
        1) Bimetal dial-type thermometer graduated in Fahrenheit mounted to measure temperature in storage and steam section of tank.

2) Graduated scale with a range of 50-300 deg F.
3) Any angle position adjustment. Stainless-steel case with nominal 5-inch- diameter face.
4) Mount thermometer in a Type 316 stainless-steel thermowell.

b. Meters and gages shall be easily readable by operator standing at grade adjacent to unit. Provide remote reading gages if required to comply with requirement.

C. Design and fabricate separator legs with bracing and gussets as necessary to meet the requirements for combined dead and live loads when intermittent blowdown separator system is completely full for seismic forces according to authorities having jurisdiction for the jobsite location.
a. Design intermittent blowdown separator system and elevating stand assembly for installation by anchoring intermittent blowdown separator system and stand assembly to floor only.

2.4 FACTORY FINISHES

A. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.

B. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.

2.5 CAPACITIES AND CHARACTERISTICS

A. Boiler Operating Pressure: 125 psig

B. Bottom Blowdown Connection: 2-inch NPT

C. Cooling Water Temperature: 60 deg F

2.6 SOURCE QUALITY CONTROL

A. Fabricate and label intermittent blowdown separator system pressure vessels according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

B. Factory install and test piping that connects boilers to separator vessel according to ASME B31.1, "Power Piping.".

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting intermittent blowdown separator system performance, maintenance, and operations.

1. Intermittent blowdown separator system locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping to verify actual locations of piping connections before installation of intermittent blowdown separator system.

C. Examine areas for suitable conditions where intermittent blowdown separator system will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Equipment Mounting:

1. Install intermittent blowdown separator system on cast-in-place concrete equipment base. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Install intermittent blowdown separator system to permit access for service and maintenance.

D. Where installing piping adjacent to machine, allow space for service and maintenance.

E. Support piping independent of equipment.

F. Install all parts and materials not factory installed.

G. Assemble and install intermittent blowdown separator system trim, components, and accessories that are not factory installed.

H. Perform cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Following

cleaning procedures, intermittent blowdown separator system shall be washed and flushed until water leaving intermittent blowdown separator system is clear.

I. Protect intermittent blowdown separator system from corrosion.

1. Before filling with water, protect by dry storage method recommended by manufacturer.
2. After filled with water, protect by wet storage method recommended by manufacturer.

3.3 PIPING CONNECTIONS

A. Bottom blowdown piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect blowdown and cooling water piping to vessel or system tappings with shutoff valves and unions or flanges at each connection.

C. Connect vessel drains, vents, makeup water, steam outlet, and continuous blowdown outlet water piping.

1. Extend drains to floor drains.
2. Extend steam outlet piping from intermittent blowdown separator to terminate above building roof in as direct a path as possible. Terminus shall incorporate an exhaust head of same pipe size.
3. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
4. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.

5. Provide a temperature-controlled, non-potable, domestic cold-water source to cool hot equipment drains to deliver a discharge temperature of 120 deg F

D. Connect chemical treatment piping to each intermittent blowdown separator system chemical treatment connection with check valve and isolation valve.

E. Where installing piping adjacent to intermittent blowdown separator system, allow space for service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and tubing connections, for compliance with requirements.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Set operating controls.
3. Verify safety controls.

B. Report: Prepare a written report to record the following:

1. Procedures used.
2. Initial findings.
3. Final results.
4. Corrective action taken to achieve compliance with requirements indicated.
5. Name and contact information for person performing testing.

3.6 ADJUSTING AND CLEANING

A. Adjust initial temperature and pressure set points.

B. Clean strainers.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain intermittent blowdown separator system.

END OF SECTION 235410

SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes shell-and-tube and gasketed-plate heat exchangers.

1.3 DEFINITIONS

A. TEMA: Tubular Exchanger Manufacturers Association.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room plan or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for heat exchanger, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Heat Exchanger: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of heat exchanger anchorage devices on which certification is based and their installation requirements.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including heat exchanger, storage tank, and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Plate Heat Exchangers:
1) Gasketed-Plate Type; One year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for heat exchangers.

B. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.

Provide Seismic Shaker Test Results / Certification that meet or exceeds site seismic requirements below;

a. Seismic Design Category C
b. Seismic Risk Category IV
c. Seismic Use Group III
d. Component Importance Factor, $I_p = 1.5$
e. Component Response Modification Factor, $R_p = 2.5$
f. Component Amplification Factor, $a_p = 1.0$
g. Short Term Spectral Response Acceleration Factor, $S_{ds} = 12.64\ \%\ g$
h. Long Period Spectral Response Acceleration Factor, $S_{d1} = 9.36\%\ g$
i. *Structural Safety Factor* **= 4.0**

2.2 GASKETED-PLATE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. API Heat Transfer Inc.
2. Alfa Laval Inc.
3. Armstrong Fluid Technology.
4. Bell & Gossett; a Xylem brand.
5. Kelvion, Inc.
6. Taco Comfort Solutions.
7. Tranter, Inc.
8. Wessels Company.

B. Configuration: Freestanding assembly, consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets. Floor-mounted heat exchangers must have integral legs with mounting feet.

C. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

D. Frame:

1. Capacity to accommodate 20 percent additional plates.
2. Painted carbon steel with provisions for anchoring to support.

E. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

1. Fabricate attachment of heat-exchanger support bars and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger support bars and guide bars are anchored to building structure.

F. End-Plate Material: Painted carbon steel.

G. Tie Rods and Nuts: Steel or stainless steel.

H. Plate Material: 0.024 inch thick before stamping; Type 304 or Type 316 stainless steel.

I. Gasket Materials: Glue free Nitrile rubber gaskets.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 and Smaller: Threaded ends in accordance with ASME B1.20.1.
2. NPS 2-1/2 and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.

K. Enclose plates in solid stainless steel removable shroud.

L. Capacities and Characteristics:

1. General: See drawing schedules

2.3 ACCESSORIES

A. Hangers and Supports:

1. Custom-built steel supports and saddles for mounting on floor.

a. Minimum Number of Saddles: two.

2. Supports and saddles to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Shroud: Stainless steel sheet.

C. Miscellaneous Components for Hot-Water Unit: Control valve, valves, thermometers, and piping. Include components fitted for electronic control.

D. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometers, and piping. Include components fitted for electronic control.

E. Pressure-Relief Valves: Cast iron Bronze Brass,, ASME rated and stamped.

1. Pressure-relief valve setting: 1.15 times maximum working pressure.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME International label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HEAT EXCHANGER, GENERAL

A. Equipment Mounting:

1. Install floor-mounted heat exchangers on cast-in-place concrete equipment bases. Install all heat exchangers level and plumb in accordance with manufacturer's recommendations. Install floor-mounted and wall-hung steam heat exchangers at sufficient height, using sufficient length supports, to achieve required steam and condensate pipe pitch. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF SHELL-AND-TUBE HEAT EXCHANGER

A. Install heat exchangers on saddle supports.

B. Heat-Exchanger Supports: Mount heat exchanger on steel saddles and supports specifically designed for each heat exchanger.

C. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

3.4 INSTALLATION OF GASKETED-PLATE HEAT EXCHANGER

A. Install wall-mounted gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

B. Install floor-mounted gasketed-plate heat exchangers on cast-in-place concrete equipment base, and fasten legs to base.

C. Install metal shroud over installed gasketed-plate heat exchanger in accordance with manufacturer's written instructions.

3.5 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

C. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

D. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

E. Install shutoff valves at heat-exchanger inlet and outlet connections.

F. Install pressure-relief valves on heat-exchanger shells where a connection has been provided on shell. When no shell pressure-relief valve connection has been provided, install pressure-relief valve on shell outlet piping before any isolation valves.

G. Install pressure-relief valves on heat-exchanger tube outlet piping before any isolation valves.

H. Pipe pressure-relief valves, full size of valve connection, to floor drain.

I. Install vacuum breaker at heat-exchanger steam inlet connection.

J. Install hose end valve to drain shell.

K. Install thermometer on each heat-exchanger fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."

L. Install pressure gauges on each heat-exchanger fluid inlet and outlet piping]. Comply with requirements for pressure gauges specified in Section 230519 "Meters and Gauges for HVAC Piping."

3.6 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. Isolate heat exchangers from piping before flushing piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blind flanges in flanged joints to isolate equipment.

C. Flush heat-exchanger piping systems with clean water; then remove and clean or replace strainer screens before reopening flow to heat exchangers.

3.7 FIELD QUALITY CONTROL

A. Testing Agency, Owner: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency, Contractor: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative:

E. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Heat exchanger will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION 235700

SECTION 236416 - CENTRIFUGAL WATER CHILLERS - **BASE BID 1 & BASE BID 2- CONTRACTOR INSTALLATION**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Applicable sections of Instructions to Bidders, IU Health General Conditions for Material Purchase, Water Cooled Rotary-Screw Water Chillers, and BID FORM.

1.2 SUMMARY

A. Section Includes:
   1. Packaged, water-cooled, electric-motor-driven centrifugal chillers.

B. Chillers have been pre-bid and purchased. **BASE BID-1 2,000 ton 4160 V and BASE BID-2 480V Heat recovery Chillers have been selected.** Contractor will receive, store and install owner's pre-purchased chillers on first floor of Central Utility Plant. Coordinate installation and provide all materials required for installation in accordance with plans, specifications, and manufacturer's installation instructions.

C. Contractor will receive heat recovery chiller submittal information from chiller vender to aid in installation and coordination of chiller.

D. Base bid items and accepted alternate bid items will be installed by contractor. List of accepted bid alternates include:
   1. Alternate -1: 2 year warranty period.

E. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input, using consistent units for any given set of rating conditions.

F. DDC: Direct digital control.

G. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

H. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated according to the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

I. kVAR: Kilovolt-ampere reactive.

J. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

K. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated according to the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

L. SCCR: Short-circuit current rating.

1.3 ACTION SUBMITTALS

A. Product Data: Provide with BID for each type of product.
1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. Performance at AHRI standard conditions and at conditions indicated.
3. Performance at AHRI standard unloading conditions.
4. Minimum evaporator flow rate.
5. Minimum condenser and heat-reclaim condenser flow rate.
6. Refrigerant capacity of chiller.
7. Oil capacity of chiller.
8. Fluid capacity of evaporator, condenser, and heat-reclaim condenser.
9. Characteristics of safety relief valves.
10. Minimum entering condenser-fluid temperature.
11. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F increments.
12. Force and moment capacity of each piping connection.

B. Sustainable Design Submittals:
1. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
2. Product Data: For energy performance. Chillers to meet or exceed ASHRAE 90.1 -2019 energy requirements at all load conditions.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Indicate chiller installed dimensions, operating weights, electrical distribution load, required clearances, location of components, and location and size of each field connection, Seismic vibration isolator support location and size.
2. Indicate how chiller is packaged for shipping. Shipping weights and dimensions of chillers. Ship refrigerant charge and oil separately in DOT approved containers.
3. Chiller performance. See Chiller Manufacturer’s Submittals.
4. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates: For certification required in "Quality Assurance" Article.

B. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control reports.

D. Field Quality-Control Reports: Startup service
1. Pre-startup inspection reports shall be performed by vendor and issued to owner, engineer, and contractor prior to startup. Should any deficiency be present that would preclude starting chillers, Vendor shall notify owner, engineer, and contractor, document issues and stop until deficiencies are corrected.
2. Vendor shall Evacuate and Charge Chillers. Provide Service record of refrigerant charging date, time, and pounds of refrigerant charged.
3. Vendor shall perform Startup Service and issue startup reports.

E. Sample Warranties: For base and add alternate extended warranties shall be provided with bid.

F. Coordination Drawings: Plans and elevations, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

B. Instructional Videos: Including those that are pre-recorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Successful bidders shall provide a Tool kit for each type of chiller provided. Tool kit to be delivered with chillers. Tool kit to include the following:
1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch high.
4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.

B. Provide Touch-up Paint with chillers: 32-oz. container of paint per chiller used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 550 certification program.

B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.

C. ASHRAE Compliance:
   1. ASHRAE 15 for safety code for mechanical refrigeration.
   2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.

F. Comply with NFPA 70.

G. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Ship each chiller fully assembled with a full charge of nitrogen.

B. Ship chiller refrigerant and oil in separate DOT approved containers.

C. Package chiller and component parts for shipping. Protect chiller with shrink wrap or similar weatherproof covering during shipping.

1.9 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
   1. Warranties include, but are not limited to, the following:
      a. Complete chiller, including compressor, drive, and refrigerant and oil charge.
      b. Parts and labor.
      c. Loss of refrigerant charge for any reason.
   2. **Base Bid Warranty Period:** One year from date of Substantial Completion.

B. Extended Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
   1. Extended warranties include, but are not limited to, the following:
      a. Complete chiller, including compressor, drive, and refrigerant and oil charge.
      b. Parts and labor.
      c. Loss of refrigerant charge for any reason.
   2. **Alternate-1 Warranty Period:** Two years from date of Substantial Completion.
   3. ~~**Alternate-2 Warranty Period:** Three years from date of Substantial Completion.~~
   4. ~~**Alternate-3 Warranty Period:** Four years from date of Substantial Completion.~~

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and will be operational after seismic event.

   2. Provide Seismic Shaker Test Results / Certification that meet or exceeds site seismic requirements below;
      a. Seismic Design Category C
      b. Seismic Risk Category IV
      c. Seismic Use Group III
      d. Component Importance Factor, **I_p = 1.5**
      e. Component Response Modification Factor, **R_p= 2.5**
      f. Component Amplification Factor, **a_p = 1.0**
      g. Short Term Spectral Response Acceleration Factor, **S_{ds} = 12.64 % g**
      h. Long Period Spectral Response Acceleration Factor, **S_{d1} = 9.36% g**
      i. Structural Safety Factor **= 4.0**

B. Condenser-Fluid Temperature Performance:
   1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 50 deg F and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
   2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F.
   3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

C. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Adjust affected chiller components to account for site altitude.

D. Performance Tolerance: Comply with AHRI 550/590:
   1. Allowable Capacity Tolerance: ± 5 percent.
   2. Allowable Full-Load Energy Efficiency Tolerance: ± 5 percent.
   3. Allowable Part-Load Energy Efficiency Tolerance: ± 5 percent.

E. ASHRAE Compliance:
   1. ASHRAE 15 for safety code for mechanical refrigeration.
   2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
   3. Applicable requirements in ASHRAE/IES 90.1-2019

F. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For Positive pressure refrigerant chillers, include an ASME U-stamp and nameplate certifying compliance.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Comply with requirements of Underwriters Laboratories and include label by a qualified testing agency showing compliance.

I. Operation Following Loss of Normal Power:
   1. Equipment associated factory- and field-installed controls and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.
   2. Provide means and methods required to satisfy requirement, even if not explicitly indicated.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   ~~1. Carrier Corporation; a unit of United Technologies Corp.~~
   2. ~~Daikin Applied.~~
   3. Trane.
   ~~4. YORK; a Johnson Controls company.~~

2.3 MANUFACTURED UNIT

A. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor VSD motor controller (where indicated), lubrication

system, evaporator, condenser, economizer, controls, interconnecting unit piping and wiring, and indicated accessories.

B. Mounting Base: Fabricate chiller mounting base from welded ASTM A36 structural steel with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to owner provided concrete housekeeping pads. Provide seismic steel weldments and anchor plates to mount under the chiller's feet

2.4 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Single-stage or multistage, variable- or dynamic-displacement, centrifugal-type compressor driven by an electric motor.

B. Oil-Free Technology: -460V Heat Recovery Chillers
   1. Compressors may have oil-free technology using a permanent magnet synchronous motor, magnetic bearings, integral variable-frequency controller, and digital electronic controls.
      a. Magnetic Bearings or Roller Element Bearings:
         1) Levitated shaft position shall be actively controlled and monitored by an X-, Y-, and Z-axis digital position sensor.
         2) Compressor assembly shall be capable of coming to a controlled, safe stop without damage during a power failure by diverting stored power to the magnetic bearing control system.
      b. Integrate monitoring and controls associated with magnetic bearings into chiller controls, including following:
         1) Operating Information: Positions, currents, temperatures, rotor elongation, and speed.
         2) Warning Messages: Vibration.
         3) Safety Shutdown: Internal fault, high bearing temperature or current, startup failure, speed signal fault, overspeed fault, communication error, rotor elongation, oscillator fault, rotor contraction, unauthorized rotation, and high and low voltage.
         4) Cycling Shutdown: Position, low-frequency displacement, vibration, speed signal fault, startup failure, serial communications fault.

C. Compressor:
   1. Casing: Cast iron, precision ground.
   2. Impeller: High-strength cast-aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.

D. Drive: Direct- or gear-drive, open or hermetic design, using an electric motor as the driver.
   1. Gear Drives:
      a. For chillers with oil-lubricated gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating.

b. For chillers with oil-free technology, gear drives shall be of single- or double-helical gear design without the need for oil while chiller is operating, starting, and stopping.
c. Gears shall comply with American Gear Manufacturer Association standards.

2. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
3. Seals: Seal drive assembly to prevent refrigerant leakage.
4.

E. Compressor Motor:
1. 460 volt Continuous-variable frequency duty, squirrel-cage, induction-type motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with open-drip proof enclosure.
5. Provide motor with thermistor or RTD in each of three-phase motor windings to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
7. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
8. Aegis motor shaft grounding ring or equivalent for each motor.

F. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
1. Overspeed Test: At least 20 percent above design operating speed.
2. Vibration Limits: Velocities not to exceed 0.15 inches/s and 0.8 mils peak to peak on all axes.

G. Service: Easily accessible for inspection and service.
1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

H. Economizers: For multistage chillers, provide interstage economizers.

I. Capacity Control: Modulating, variable speed, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve indicated performance.
1. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to 15 percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range based on chiller application:

a. Constant-design of entering condenser-fluid temperature for heat recovery chiller operation.
b. Drop-in entering condenser-fluid temperature of 2.5 deg F for each 10 percent in capacity reduction for normal centrifugal chiller operation.

4. Chillers with variable-frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
5. Avoid use of hot-gas bypass if other options are available to achieve performance indicated. Apply hot-gas bypass according to ASHRAE/IES 90.1 and governing codes.

J. Oil Lubrication System: Consisting of pump, filtration, cooler, factory-wired power connection, and controls.
1. Bearings, gears, and other rotating surfaces shall be lubricated at all operating, startup, coast down, and standby conditions, including power failure.
2. Manufacturer's standard method to remove refrigerant from oil.
3. Oil filter shall be the easily replaceable cartridge type, minimum 0.3-micron efficiency, with means of positive isolation while servicing.
4. Refrigerant- or water-cooled oil cooler.
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.

2.5 REFRIGERATION

A. Refrigerant: Preferred refrigerants are nonflammable next generation ASHRAE 34 Class A1 or B1 low global warming potential (GWP) refrigerant with GWP ≤ 700. Contractor shall select a refrigerant listed in section B below. Base bids for centrifugal chillers and heat recovery chillers shall use a next generation low GWP refrigerant to enable project to meet LEED NC v-4 Enhanced Refrigerant Management requirements. R-134a may be used in voluntary alternate bid equipment. Benefits and final refrigerant selection will be determined by IUH during the bid evaluation.

B. The chiller refrigerant quantity, leakage and management shall be eligible for LEED NC v4 Energy and Atmosphere Credit – Enhanced Refrigerant Management requirements. Refrigerants that may meet requirements include:
1. R-513A; ASHRAE 34, Class A1, GWP=573
2. R-514A; ASHRAE 34, Class B1. GWP=2
3. R-1233zd, ASHRAE 34, Class A1, GWP=1
4. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures

C. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

D. Pressure Relief Device:
1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Provide

manufacturer's single or multiple standard spring-loaded reseating type pressure relief valves.

2. Rupture discs may be provided in series with pressure relief valves. Rupture discs alone are unacceptable.
3. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
4. Where dual pressure relief devices are installed in series, provide a sensor with indicator between devices to indicate refrigerant release past first device.

E. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system and for charging chiller. Comply with requirements in ASHRAE 15 and ASHRAE 147.

F. Refrigerant Isolation for Chillers:
1. Factory install positive shutoff, manual isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.
2. Suction side of compressor from evaporator shall have an isolation valve to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.

G. Purge System:
1. For chillers operating at sub atmospheric pressures factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of non-condensables, including, but not limited to, water, water vapor, and non-condensable gases.
2. System shall be of thermal purge design, refrigerant or air cooled, and equipped with a carbon filter that includes an automatic regeneration cycle.
3. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
4. Construct components of noncorrodible materials.
5. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
6. Efficiency of not more than 0.02 lb. of refrigerant per pound of air when rated according to AHRI 580.
7. Operation independent of chiller according to ASHRAE 147.

H. Positive-Pressure System:
1. For chillers operating at sub atmospheric pressures, factory install an automatic positive-pressure system.
2. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant-pressure vessel of not less than 0.5 psig adjustable up to a pressure that remains within the vessel design pressure limits.
3. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.

2.6 EVAPORATOR

A. Description: ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 Shell-and-tube design, with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent liquid refrigerant carryover from entering compressor.

D. Evaporator shall have sight glass or other form of positive visual verification of liquid-refrigerant level.

E. Tubes:
1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper, copper-nickel alloy, stainless steel, or titanium.
4. Nominal OD: Manufacturer's choice. ¾” or 1”
5. Minimum Wall Thickness: 0.028 inch.
6. External Finish: Manufacturer's standard.
7. Internal Finish: Enhanced or smooth.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear, but not more than 4 feet apart.

H. Hinged Water Boxes:
1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Hinged Marine type for water box with piping connections; Hinged standard type for water box without piping connections. Marine and standard water boxes and tube covers on condensers and evaporators shall be hinged to provide access to service tubes without the need for lifting devices.
3. Provide eyebolts or lifting lugs to allow removal of water box covers and marine water-box covers from their hinges. These cover lifting lugs will be in addition to the hinges on water boxes and marine water boxes.
4. Nozzle Pipe Connections: Grooved with mechanical-joint coupling and flexible coupling flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4- or 1-inch drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:
   1. Electrolytic corrosion-inhibitor anode, zinc or magnesium.
   2. Coat wetted surfaces with a corrosion-resistant finish.
   3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

J. Flow Sensor: Thermal dispersion type, factory calibrated and field adjustable for project-specific application.

2.7 CONDENSER

A. Description: ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 Shell-and-tube design, with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.

D. Condenser shall have sight glass or other form of positive visual verification of refrigerant charge and condition.

E. Tubes:
   1. Individually replaceable from either end and without damage to tube sheets and other tubes.
   2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
   3. Material: Copper, copper-nickel alloy, stainless steel, or titanium.
   4. Nominal OD: Manufacturer's choice 3/4 or 1 inch.
   5. Minimum Wall Thickness: Manufacturer's choice 0.028 inch minimum.
   6. External Finish: Manufacturer's standard.
   7. Internal Finish: Enhanced or smooth.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear, but not more than 4 feet apart.

H. Water Box:
   1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   2. Hinged Marine type for water box with piping connections; standard Hinged type for water box without piping connections. Marine and standard water boxes and

tube covers on condensers and evaporators shall be hinged to provide access to service tubes without the need for lifting devices.

3. Provide eyebolts or lifting lugs to allow removal of water box covers and marine water-box covers from their hinges. These cover lifting lugs will be in addition to the hinges on water boxes and marine water boxes.
4. Nozzle Pipe Connections: Grooved with mechanical-joint coupling and flexible coupling flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4- or 1-inch drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:
1. Electrolytic corrosion-inhibitor anode, zinc or magnesium.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

J. Flow Sensor: Thermal dispersion type, factory calibrated and field adjustable for project-specific application.

2.8 INSULATION

A. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.
1. Thickness: 3/4 inch for standard centrifugal chillers; 1 ½" for heat recovery chillers.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
5. Manufacturer has option to factory or field insulate chiller components installed in multiple pieces to reduce potential for damage during installation.
6. Manufacturer has option to factory or field insulate water boxes and nozzles to reduce potential for damage during installation.

D. Field-Applied Insulation:

1. Components that are not factory insulated shall be field insulated to comply with requirements indicated.
2. Manufacturer shall be responsible for chiller insulation whether factory or field installed, to ensure manufacturer is the single point of responsibility for chillers.
3. Manufacturer factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
4. After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.9 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Provide Single-point, field-power connection to fused disconnect switch or breaker for both low voltage 460-volt chillers and medium voltage 4160-volt chillers

C. **Low Voltage 460-volt chillers** shall have minimum short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 100,000 A.

D. Medium Voltage 5KV chillers shall have minimum short circuit current rating (SCCR) according to UL 347, NEMA ICS3 shall be as required by electrical power distribution system, but not less than 42,000 A.

E. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring. terminal block for connection to external controls or equipment.

F. Factory-installed wiring located outside of enclosures shall be installed in metal raceway, and terminal connections shall be made with not more than a 24-inch length of liquid tight conduit.

G. Factory install and wire capacitor bank for 5KV starters for the purpose of power factor correction to 0.95 at all operating conditions. 460 V VSD drives do not require capacitor bank power correction capacitors.
   1. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as that for motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
   2. Capacitors shall be of non-PCB dielectric fluid, metallized electrode design, with low loss with low-temperature rise. The kVAR ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
   3. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
   4. Provide a ground terminal and a terminal block or individual connectors for phase connection.

2.10 MOTOR CONTROLLER- 5KV Medium Voltage Non-Heat Recovery Chillers

A. Enclosure: Factory installed, unit mounted, NEMA 250, Type 12, with hinged full-front access door with lock and key or padlock and key.

B. Control Circuit: Obtained from integral control power transformer with a control power transformer source of enough capacity to operate connected control devices.

C. Overload Relay shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.

D. Provide Manufacturer's standard 65% unit mounted medium Autotransformer Reduced Voltage starter or Solid-State Reduced Voltage Soft Starter.

E. Autotransformer Reduced-Voltage Controller: NEMA ICS 3, UL: 347 closed transition; include isolation switch and current-limiting fuses.

F. Solid-State, Reduced-Voltage Controller: NEMA ICS 3, UL 347
   1. Include surge suppressor in solid-state power circuits to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   2. Visual indication of motor and control status, including the following conditions:
      a. Controller on.
      b. Overload trip.
      c. Loss of phase.
      d. Starter fault.

G. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
   1. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch. Short circuit current rating (SCCR) according to UL 347 shall be as required by electrical power distribution system, but not less than 42,000 A.
   2. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 3, UL 347 heavy-duty type.
   3. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
   4. Control Relays: Time-delay relays.
   5. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
   6. Total Run Time: Numerical readout in hours on face of enclosure
   7. Realtime clock with current time and date.
   8. Number-of-Starts Counter: Numerical readout on face of enclosure.
   9. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
      a. Selectable, digital display of the following:
         1) Phase Currents, Each Phase: Plus or minus 1 percent.
         2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
         3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.

4) Three-Phase Real Power: Plus or minus 2 percent.
5) Three-Phase Reactive Power: Plus or minus 2 percent.
6) Power Factor: Plus or minus 2 percent.
7) Frequency: Plus or minus 0.5 percent.
8) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.
9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

b. Mounting: Display and control unit flush or semi recessed in instrument compartment door.

10. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
11. Power Protection: Chiller shall shut down within six cycles of power interruption.

2.11 VARIABLE-FREQUENCY CONTROLLER - ***460 Volt Heat Recovery Chillers***

A. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.

B. Description: NEMA ICS 2; listed and labeled according to UL 508 as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.

C. Enclosure: Unit mounted, NEMA 250, Type 12, with hinged full-front access door with lock and key.

D. Integral Disconnecting Means: Door-interlocked, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 100,000 A.

E. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors; suitable for variable torque loads.

F. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
1. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
2. Regulator shall provide full digital control of frequency and voltage.
3. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage for application to a squirrel-cage motor. Inverter shall produce a sine coded, PWM output waveform and shall conduct no RFI back to the input power supply.

G. Output Rating: Three phase, with voltage proportional to frequency throughout voltage range.

H. Operating Requirements:
1. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum.
2. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
3. Capable of driving full load, without derating, under the following conditions:
   a. Ambient Temperature: Zero to 50 deg C.
   b. Relative Humidity: Up to 95 percent (noncondensing).
   c. Altitude: Up to 3300 feet.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter; 98 percent with harmonic filter.
6. Overload Capability: 1.05 times the full-load current for seven seconds.
7. Starting Torque: As required by compressor-drive assembly.
8. Speed Regulation: Plus or minus 1 percent.
9. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
10. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
11. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

I. Internal Adjustability Capabilities: Integral to controller or through chiller control panel.
1. Minimum Output Frequency: 6 Hz.
2. Maximum Output Frequency: 60 Hz.
3. Acceleration: Two seconds to a minimum of 60 seconds.
4. Deceleration: Two seconds to a minimum of 60 seconds.
5. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

J. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
1. Overtemperature.
2. Short circuit at controller output.
3. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
4. Open circuit at controller output.
5. Input undervoltage.
6. Input overvoltage.
7. Loss of input phase.
8. Reverse phase.
9. AC line switching transients.
10. Instantaneous overload, line to line or line to ground.
11. Sustained overload exceeding 100 percent of controller-rated current.
12. Starting a rotating motor.

K. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

L. Automatic Reset and Restart:
1. Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
2. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

M. Visual Indication: On face of controller enclosure or chiller control enclosure. indicating the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.
7. Motor speed (percent).
8. Fault or alarm status (code).
9. DC-link voltage.
10. Motor output voltage.
11. Input kilovolt amperes.
12. Total power factor.
13. Input kilowatts.
14. Input kilowatt-hours.
15. Three-phase input voltage.
16. Three-phase output voltage.
17. Three-phase input current.
18. Three-phase output current.
19. Three-phase input voltage THD.
20. Three-phase input current THD.
21. Output frequency (Hertz).
22. Elapsed operating time (hours).
23. Diagnostic and service parameters.

N. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

O. Control Signal Interface:
1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
2. Manufacturer has option to incorporate control signal interface into chiller control panel.

P. Active Harmonic Distortion Filter:
1. Factory mounted and wired to limit total voltage and current distortion to 5 percent.
2. Factory mounted and wired to limit total demand distortion (TDD) to 5 percent of unit input.

Q. Cooling: Air cooled.

R. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
1. Control Relays: Auxiliary and adjustable time-delay relays.

S. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

2.12 CONTROLS

A. Control: BACNET IP compliant. BTL listed. Standalone and microprocessor based, with all memory stored in nonvolatile memory, so that reprogramming is not required on loss of electrical power.

B. Enclosure: Unit mounted, NEMA 250, Type 12, hinged or lockable, factory wired with a single-point, with field-power connection and a separate control circuit.

C. Factory-installed wiring outside of enclosures shall be in a NFPA 70-approved raceway. Make terminal connections with liquid tight or flexible metallic conduit.

D. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
1. Date and time.
2. Operating or alarm status.
3. Fault history with not less than last 10 faults displayed.
4. Set points of controllable parameters.
5. Trend data.
6. Operating hours.
7. Number of chiller starts.
8. Outdoor-air temperature or space temperature if required for chilled-water reset.
9. Entering- and leaving-fluid temperatures of evaporator and condenser.
10. Difference in fluid temperatures of evaporator and condenser.
11. Fluid flow of evaporator and condenser.
12. Fluid-pressure drop of evaporator and condenser.
13. Refrigerant pressures in evaporator and condenser.
14. Refrigerant saturation temperature in evaporator and condenser shell.
15. Compressor refrigerant suction and discharge temperature.
16. Compressor bearing temperature.
17. Motor bearing temperature.
18. Motor winding temperature.
19. Oil temperature.
20. Oil discharge pressure.

21. Phase current.
22. Percentage of motor-rated load amperage.
23. Phase voltage.
24. Demand power (kilowatts).
25. Energy use (kilowatt-hours).
26. Power factor.
27. For chillers equipped with variable-frequency controllers and harmonic filters, include the following:
    a. Output voltage and frequency.
    b. Voltage THD for each phase.
    c. Supply current TDD for each phase.
    d. Inlet vane position.
    e. Controller internal ambient temperature.
    f. Heatsink temperature.
28. Purge suction temperature if purge system is provided.
29. Purge elapsed time if purge system is provided.

E. Control Functions:
1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator-fluid temperature shall be reset based on set point temperature.
3. Current limit and demand limit.
4. Condenser-fluid temperature.
5. External chiller emergency stop.
6. Variable evaporator flow.
7. Thermal storage.
8. Heat reclaim. For heat recovery chillers

F. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
1. Low evaporator pressure or temperature; high condenser pressure.
2. Low evaporator-fluid temperature.
3. Low oil differential pressure.
4. High or low oil pressure.
5. High oil temperature.
6. High compressor-discharge temperature.
7. Loss of condenser-fluid flow.
8. Loss of evaporator-fluid flow.
9. Motor overcurrent.
10. Motor overvoltage.
11. Motor undervoltage.
12. Motor phase reversal.
13. Motor phase failure.
14. Sensor- or detection-circuit fault.
15. Processor communication loss.
16. Motor controller fault.
17. Extended compressor surge.
18. Excessive air-leakage detection.

G. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

H. Security Access: Provide electronic security access to controls through identification and password, with at least three levels of access: view only; view and operate; and view, operate, and service.

I. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

J. Communication Port: Modbus TCP/IP over ethernet through RS-232 port, USB 2.0 port or higher, or equivalent connection capable of connecting a printer and a notebook computer.

K. BAS DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display chiller status and alarms.
   1. Hardwired I/O Points:
      a. Monitoring: On-off status, common trouble alarm electrical power demand (kilowatts) electrical power consumption (kilowatt-hours) power factor.
      b. Control: On-off operation, chilled-water discharge temperature set-point adjustment, electrical power demand limit, condenser water discharge temperature set point for heat recovery chillers
   2. Communication Interface: Modbus TCP/IP over ethernet ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control and monitor the chiller from an operator workstation.
      a. Control features and monitoring points displayed locally at chiller control panel shall be available through the control system, including, as a minimum, the following:
         1) Start-stop command from remote source.
         2) Unit control source, local, analog, digital or modem.
         3) Chiller control panel start-stop.
         4) Accumulated operating hours.
         5) Accumulated starts.
         6) Compressor motor status.
         7) Unit operation code.
         8) Unit safety fault code.
         9) Unit cycling fault code.
         10) Chilled-water pump status.
         11) Chilled-water flow proof.
         12) Chilled water entering temperature.
         13) Chilled water leaving temperature.
         14) Chilled-water leaving temperature set-point adjustment from remote source.
         15) Condenser(s) water entering temperature.
         16) Condenser(s) water leaving temperature.
         17) Evaporator refrigerant pressure.
         18) Condenser(s) refrigerant pressure.
         19) Evaporator refrigerant saturation temperature.

20) Condenser(s) refrigerant saturation temperature.
21) Refrigerant discharge temperature.
22) Refrigerant level.
23) Refrigerant liquid level set point.
24) Oil pressure differential.
25) Oil sump pressure.
26) Oil pump pressure.
27) Oil sump temperature.
28) High-speed thrust bearing proximity position.
29) High-speed thrust bearing proximity reference.
30) Motor current percent of full-load amps.
31) Motor current phase A.
32) Motor current phase B.
33) Motor current phase C.
34) Motor current set-point adjustment from remote source.
35) Motor bearing shaft end vibration.
36) Motor bearing opposite shaft end vibration.
37) Motor bearing shaft end temperature.
38) Motor bearing opposite shaft end temperature.
39) Motor average winding temperature.
40) Variable-frequency controller selection, auto or fixed.
41) Variable-frequency controller output voltage.
42) Variable-frequency controller input power, rate.
43) Variable-frequency controller input power, consumption.
44) Variable-frequency controller DC bus voltage.
45) Variable-frequency controller inverter link current.
46) Variable-frequency controller output frequency.
47) Variable-frequency controller internal ambient temperature.
48) Variable-frequency controller converter heatsink temperature.
49) Variable-frequency controller harmonic filter installed, true or false.
50) Harmonic Filter THD at maximum voltage, percent.
51) Harmonic filter total demand distortion at maximum current, percent.
52) Harmonic filter total supply kVA.
53) Anti-recycle time remaining.
54) Liquid line solenoid.
55) Pre-rotation vanes position.
56) Adaptive capacity control valve surge map installed, true or false.
57) Adaptive capacity control new surge point, true or false.
58) Adaptive capacity control surge type, pressure differential or current.
59) Adaptive capacity control surge count.
60) Adaptive capacity control PRV position.
61) Adaptive capacity control output frequency.

L. Quick-Start Feature:
1. Automatically restore chiller operation up to 100 percent capacity within three minutes after a 15 -second power interruption.

2. Quick-start feature shall ensure guide vanes remain open following a power interruption event and quick ramp-up speed logic is employed to facilitate shortest time to deliver chilled water at set-point temperature.
3. Chiller manufacturer shall provide integral UPS unit(s) with chiller controls if required to keep chiller integral controls operational to comply with requirement.
4. Chiller manufacturer shall demonstrate chiller start time with the quick-start feature enabled while simulating power fault, power service return, restart time, and capacity control, to produce desired chilled-water temperature at load indicated.

2.13 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
1. Provide at least one coat of primer with a total dry film thickness of at least 2 mils.
2. Provide at least two coats of alkyd-modified vinyl enamel, epoxy, or polyurethane finish with a total dry film thickness of at least 4 mils.
3. Paint surfaces that are to be insulated before applying the insulation.
4. Paint installed insulation to match adjacent uninsulated surfaces.
5. Color of finish coat shall be manufacturer's standard.
6. Provide one quart of finish paint per chiller for touchup of installed chiller.

2.14 ACCESSORIES

A. Flow Switches:
1. Chiller manufacturer shall furnish a switch for each evaporator and condenser and verify field-mounting location before installation.
2. Thermal Dispersion Flow Switches
   a. Electronic Thermal Dispersion switch; Flow Set point programable
   b. DPDT relay contacts, 6 amps at 115 Vac
   c. Temperature range: -40 F to 350 F
   d. ¾” NPT SS wetted parts
3. Paddle Flow Switches:
   a. Vane operated to actuate a double-pole, double-throw switch, with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
   b. Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
   c. Pressure rating equal to pressure rating of heat exchanger.
   d. Construct body and wetted parts of Type 316 stainless steel.
   e. House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
   f. Vane length to suit installation.
4. Pressure-Differential Switches:
   a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.

b. Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
c. Set Point: Screw type, field adjustable.
d. Electrical Connections: Internally mounted screw-type terminal blocks.
e. Switch Enclosure: NEMA 250, Type 4.
f. Switch Action: Double-pole, double-throw switch, with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

B. Vibration Isolation:
1. Chiller manufacturer shall furnish seismic withstand restraints for each chiller.
2. Provide Steel weldments to restrain chillers in accordance with chiller seismic certification. Provide anchorage and loads equipment pad/ concrete floor will be exposed to.

C. Sound Barrier:
1. Provide sound barrier only if required to comply with sound requirements indicated.
2. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
3. Provide for repeated installation and removal without use of tape or calk.
4. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
5. Covers shall be double sewn and lock stitched, with edges folded and sewn so no raw cut edges are exposed.
6. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
7. Continuously lap all exposed seams at least 2 inches for better sound containment.
8. Permanently label each section of cover to indicate its location, description, size, and number sequence.
9. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

2.15 BASE BID-1 NON HEAT RECOVERY CHILLERS

A. Capacity 2,000 tons.

B. Quantity: Six Chillers.

C. Efficiency:
1. Meet or exceed ASHRAE 90.1-2019 adjusted efficiency requirements.

D. Evaporator:
1. Pressure Rating:150 psig water side
2. Number of Passes: Two.

3. Fluid Type: Water.
4. Design Fluid Flow Rate: 3000 gpm.
5. Minimum Fluid Flow Rate: ≤ 25 % of design flow.
6. Entering-Fluid Temperature: 58 deg F.
7. Leaving-Fluid Temperature: 42 deg F.
8. Fluid-Pressure Drop: 18 feet of head.
9. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.

E. Condenser:
1. Pressure Rating: 150 psig water side.
2. Number of Passes: Two.
3. Fluid Type: Water.
4. Design Fluid Flow Rate: 6000 gpm.
5. Minimum Fluid Flow Rate: ≤ 2316 gpm.
6. Entering-Fluid Temperature: 85deg F.
7. Leaving-Fluid Temperature: 95 F.
8. Fluid-Pressure Drop: 27 feet of head.
9. Fouling Factor: 0.00025 sq. ft. x h x deg F/Btu.

F. Compressor:
1. Number of Compressors: one or two, single or multiple stage.
2. Refrigerant: low GWP refrigerant selected by chiller manufacturer.
3. Compressor Drive: Unit Mounted Constant Speed 4160V, 3 phase Motor
4. Compressor Motor Starter: Unit Mounted Reduced Voltage Starter.
   a. Autotransformer
   b. Reduced Voltage Solid State Drive

G. Chiller Control Electrical Requirements:
1. Power Connections: Integral Branch circuit with step down control transformer.
2. Power Input: Size as determined by manufacturer.
3. Minimum Circuit Ampacity: Size as determined by manufacturer.
4. Maximum Overcurrent Protection Device: Fused branch circuit. Size as determined by manufacturer.
5. Volts: 120-V ac.
6. Phase: Single.
7. Hertz: 60.

H. Chiller Electrical Requirements:
1. Single point power connection with Auto-Transformer Starter or Reduced Voltage Starter.
2. Power Input: ≤ 1175 kW.
3. Power Factor: 0.95.
4. FLA amps: ≤ 190
5. Minimum Circuit Ampacity: ≤ 235 A.
6. Maximum Overcurrent Protection Device:≤ 400 A.
7. Volts: 4160 -VAC.
8. Phase: Three.
9. Hertz: 60.

I. Noise Rating: Less than 85 -dBA sound power level when measured according to AHRI 575. Provide factory-installed sound treatment if necessary to achieve performance indicated.

2.16 BASE BID-2 HEAT RECOVERY CHILLERS

A. Capacity: Nominal 300 tons each arranged in parallel flow as required to meet heating hot water and chilled water entering/ leaving conditions.

B. Quantity: Six Chillers.

C. Efficiency:
1. Meet or exceed ASHRAE 90.1-2019 adjusted efficiency.
2. Heating only FL COP ≥ 3.465
3. Full Load Simultaneous Heating and Cooling: 130 deg F leaving heating water temperature COP ≥ 5.99

D. Evaporator: Variable flow
1. Pressure Rating:150 psig water side
2. Number of Passes: Two.
3. Fluid Type: Water.
4. Minimum Fluid Flow Rate: ≤ 295 gpm.
5. Design Fluid Flow Rate: 450 gpm.
6. Parallel Flow Heat Recovery or Cooling Only Entering-Fluid Temperature: 58 deg F
7. Parallel Flow Heat Recovery or Cooling Only Leaving-Fluid Temperature: 42 deg F.
8. Design Flow Fluid-Pressure Drop: ≤ 17 feet of head per chiller (Parallel flow);
9. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.

E. Condenser: Variable Flow Heat Recovery; Constant Flow Cooling Only
1. Pressure Rating: 150 psig water side.
2. Number of Passes: Two.
3. Fluid Type: Water.
4. Heat Recovery Design Fluid Flow Rate: 540 gpm.
5. Cooling Only Design Fluid Flow Rate: 1080 gpm
6. Minimum Fluid Flow Rate: ≤ 434 gpm
7. Maximum Fluid Flow Rate: ≥ 1318.
8. Parallel Flow Heat Recovery Entering-Fluid Temperature: 100 deg F.
9. Parallel Flow Heat Recovery Leaving Fluid Temperature: 120 deg F.
10. Cooling Only Entering-Fluid Temperature: 88 deg F.
11. Cooling Only Leaving-Fluid Temperature: 98 deg. F.
12. Heat Recovery Fluid-Pressure Drop: ≤ 7.1 feet of head per chiller (Parallel Flow)
13. Cooling only fluid pressure drop ≤ 15.5 ft of head.
14. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.

F. Compressor:

1. Number of Compressors: one or two, single or multiple stage.
2. Refrigerant: low GWP refrigerant selected by chiller manufacturer.
3. Compressor Drive: Nominal 400 HP Unit Mounted Variable Speed 460V 3 phase Motor
4. Compressor Motor Starter: Unit Mounted VFD.

G. Chiller Control Electrical Requirements:
1. Power Connections: Integral branch circuit with step down control transformer.
2. Power Input: size as determined by manufacturer.
3. Minimum Circuit Ampacity: size as determined by manufacturer.
4. Maximum Overcurrent Protection Device: fused branch circuit.
5. Volts: 120-V ac.
6. Phase: Single.
7. Hertz: 60.

H. Chiller Electrical Requirements:
1. Single point power connection with variable speed starter.
2. Power Input: ≤ 326 kW.
3. Power Factor: 0.95.
4. FLA amps: ≤ 466 A
5. Minimum Circuit Ampacity: ≤ 590A.
6. Maximum Overcurrent Protection Device: ≤ 1,000 A.
7. Volts: 460V ac.
8. Phase: Three.
9. Hertz: 60.

I. Noise Rating: less than 85 -dBA sound power level when measured according to AHRI 575. Provide factory-installed sound treatment if necessary to achieve performance indicated.

2.17 SOURCE QUALITY CONTROL

A. Perform functional run tests of chillers before shipping.

B. Notify Owner in writing four weeks before Performance and Sound testing so Owner may witness testing.

C. Factory Performance Testing:
1. Factory performance test chillers, before shipping, according to AHRI 550/590.
2. Test the following conditions:
a. Design conditions indicated.
b. Reduction in capacity from design to minimum load in steps of 10 % with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F increments.
c. At four point(s) of varying part-load performance to be selected by Owner at time of test.

3. Allow Owner access to place where chillers are being tested. Notify Owner in writing at least 30 days in advance of testing.
4. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

D. Factory Sound Testing:
1. Factory sound test chillers, before shipping, according to AHRI 575.
2. Test the following conditions:
   a. Design conditions indicated.
   b. Chiller operating at calculated worst-case sound condition.
   c. At four point(s) of varying part-load performance to be selected by Owner at time of test.
3. Allow Owner access to place where chillers are being tested. Notify Owner in writing at least 30 days in advance of testing.
4. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

E. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of 45 psig. Vacuum and pressure test for leaks.

F. Eddy Current Testing:
1. Perform factory testing of evaporator and condenser tubes of each chiller to ensure tube quality and longevity.
2. Submit test report, including, as a minimum:
   a. List of equipment used and equipment settings.
   b. Test data reports and accompanying strip charts of calibrations.
   c. Identify tubes with significant defects and typical indications.
   d. Statistical summary of defect indications.
   e. Recommendations concerning tube condition, tube replacement, tube removal for evaluation, and future frequency of testing.
   f. Approval by an American Society for Nondestructive Testing, Level III eddy current technician.

G. Owner Travel Expenses:
1. Include cost associated with Owner travel expenses to witness factory testing. Total value attributed to travel expenses shall be clearly indicated.
2. Expenses shall include roundtrip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, dinner), out-of-town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for two Owner representative(s) with origin of Indianapolis, IN.

3.1 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, control and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.
   1. Chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and control and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. INSTALLATION OF CENTRIFUGAL WATER CHILLERS

E. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

F. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

G. Install chillers on support structure indicated.

H. Equipment Mounting:
   1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
   3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

I. Maintain manufacturer's recommended clearances for service and maintenance.

J. Maintain clearances required by governing code.

K. Chiller manufacturer's factory-trained service personnel are to charge chiller with refrigerant and fill with oil if not factory installed.

L. Install separate devices furnished by manufacturer and not factory installed.
   1. Chillers shipped in multiple major assemblies are to be field assembled by chiller manufacturer's factory-trained service personnel.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 Hydronic Piping Specialties," and Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to chillers, allow space for service and maintenance.

C. Evaporator-Fluid Connections:
   1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gauge.
   2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve.
   3. Make connections to chiller with a flange or mechanical coupling.

D. Condenser-Fluid Connections:
   1. Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gauge.
   2. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve.
   3. Make connections to chiller with a flange or mechanical coupling.

E. Refrigerant-Pressure Relief Device Connections:
   1. For chillers installed indoors, extend separate vent piping for each chiller to the outdoors without valves or restrictions.
   2. Comply with ASHRAE 15.
   3. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

F. For chillers equipped with a purge system, extend separate purge vent piping for each chiller to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.

G. Connect each chiller drain connection with a drain valve, which is full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.

H. Connect each chiller water box vent connection with an automatic or manual vent, which is full size of vent connection.

3.3 ELECTRICAL POWER CONNECTIONS

A. Connect wiring to Single-point, field-power connection fused disconnect switch or breaker for both low voltage 460-volt chillers and medium voltage 4160-volt chillers.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between chiller control interface and DDC control system for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Install nameplate on face of chiller control panel indicating the control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least 0.5 inch high.

3.5 STARTUP SERVICE – Provided by Chiller Vendor.

A. Contractor shall contact chiller vendor and owner when chiller is ready for start-up. Vendor’s bid shall include startup services. Contractor shall be present to correct any deficiencies discovered during checkout and startup.
   1. Complete installation and startup check according to manufacturer's written instructions.
   2. Verify control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.
   3. Charge chiller with and oil. Verify refrigerant charge is sufficient, and chiller has been leak tested.
   4. Verify that pumps are installed and functional.
   5. Verify that thermometers and gages are installed.
   6. Operate chiller for run-in period.
   7. Check bearing lubrication and oil levels.
   8. Verify that refrigerant pressure relief device is vented outside.
   9. Verify proper motor rotation.
   10. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
   11. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
   12. Verify and record performance of chiller protection devices.
   13. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, piping, controls and electrical connections for proper assembly, installation, and connection.

C. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

D. Prepare and submit pre-startup reports prior to starting chillers. Obtain owners sign-off before commencing chiller startup.

E. Prepare and submit chiller startup reports. Adjust system flows, set points, alarms, and timers for stable operation.

3.6 WARRANTY PERIOD TESTING– Provided by Chiller Vendor.

A. Prior to and within one month of warranty period expiration, perform testing, analysis, and reporting indicated below for each chiller.

B. Eddy Current Testing:
1. Solicit services of a third-party testing agency, specializing in such analysis, to perform testing of evaporator and condenser tubes, to ensure tube quality and longevity.
2. Submit test report to Owner, including, as a minimum:
   a. List of equipment used and equipment settings.
   b. Test data reports and accompanying strip charts of calibrations.
   c. Identify tubes with significant defects and typical indications.
   d. Statistical summary of defect indications.
   e. Recommendations concerning tube condition, tube replacement, tube removal for evaluation, and future frequency of testing.
   f. Approval by an American Society for Nondestructive Testing, Level III eddy current technician.

C. Oil Analysis:
1. Take oil sample and solicit services of a third-party testing agency, specializing in such analysis, to perform oil analysis.
2. Submit analysis results and recommendations to Owner.

D. Refrigerant Analysis:
1. Take refrigerant sample and solicit services of a third-party testing agency, specializing in such analysis, to perform refrigerant analysis.
2. Submit analysis results and recommendations to Owner.

E. Site Access and Scheduling:
1. Contact Owner to schedule testing at least 30 days in advance of testing.
2. Make mutually agreeable schedule adjustments to accommodate Owner's request for testing.
3. Review, with Owner, requirements for visitors in advance of testing.
4. Comply with Owner requirements for visitors while on-site.

3.7 DEMONSTRATION– Provided by Chiller Vendor.

A. Contractor shall contact chiller vendor, engineer and owner when chillers are fully operational without faults and temperature controls are final adjusted. Chiller vendor representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.
   1. Instructor shall be factory trained and certified.
   2. Provide not less than 16 hours of training spread across consecutive days, not to exceed eight hours per day for each type of chiller bid.
   3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
   4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
   5. Obtain Owner sign-off that training is complete.
   6. Owner training shall be held at Project site.

END OF SECTION 236416

SECTION 236514.14 - OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS- **CONTRACTOR INSTALLATION**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Applicable sections of Instructions to Bidders, IU Health General Conditions for Material Purchase, and BID FORM.

1.2 SUMMARY

A. Section includes factory-assembled, open-circuit, induced-draft, crossflow cooling towers.

B. Cooling towers have been pre-bid and purchased. **BASE BID-1 single cell 2,000 ton cooling towers have been selected.** Contractor will receive, store and install owner's pre-purchased cooling towers on roof of Central Utility Plant. Coordinate installation and provide all materials required for installation in accordance with plans, specifications, and manufacturer's installation instructions.

C. Contractor will receive cooling tower submittal information from cooling tower vender to aid in installation and coordination of cooling tower.

D. Base bid items and accepted alternate bid items will be installed by contractor. List of accepted bid alternates include:

1. ~~**Alternate -1: Stainless steel casing.**~~
2. **Alternate-2.: Basin Sweeper piping and nozzles.**
3. **Alternate-5.: Fan vibration transmitter.**
4. **Alternate-6: External Ladders w/ safety cages**
5. ~~**Alternate-7: External Access Collector Basin Level Platforms**~~
6. **Alternate-8: Additional Walkway/ platforms W/ Handrails Between Cooling Towers at Fan Deck Level**

E. Contractor will provide VFD Drives for the cooling towers. Coordinate VFD installation with electrical contractor.

1.3 DEFINITIONS

A. SCCR: Short-circuit current rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, pressure drop, fan performance data, rating at selected points indicated, and furnished specialties and accessories.
2. Maximum flow rate.
3. Minimum flow rate.
4. Pressure required at cooling tower supply piping connections.
5. Pressure required at collection basin sweeper supply piping connections.
6. Drift loss as percent of design flow rate.
7. Sound:
    a. Sound pressure levels for operation with fan off, fan at minimum speed, and design speed. If sound requirements are indicated at a specific distance, submit performance using same distance for comparative analysis.
    b. Sound power levels in eight octave bands for operation with fans off, fans at minimum speed, and design speed.
8. Performance curves for the following:
    a. Varying entering-water temperatures from design to minimum in one-degree temperature increments.
    b. Varying ambient wet-bulb temperatures from design to minimum in one-degree temperature increments.
    c. Varying fan operation from design to minimum speed in 10 percent speed increments, and with fan off.
9. Fan airflow at design conditions, brake horsepower, and drive losses (indicated in horsepower and percent of brake horsepower).
10. Fan motor electrical characteristics including, but not limited to, speed, voltage, phase, hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
11. Electrical power requirements for each cooling tower component requiring power.
12. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
13. Assembled unit dimensions.
14. Diagram showing each separate piece requiring field assembly.
15. Shipped sub-assembly dimensions and weights for field assembly.
16. Assembled unit weight without water.
17. Operating weight and load distribution.
18. Unit vibration isolation and seismic controls.
19. Required clearances for maintenance and operation.
20. Sizes and dimensioned locations of piping and wiring connections.
21. Diagrams for power, signal, and control wiring.
22. Recommended cooling tower structural support bearing area and location.

B. Delegated-Design Submittal: For alternate bid cooling tower interconnecting access platforms, handrails and access ladders indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of access platforms, ladders and handrail support.

2. Detail fabrication including anchorages and attachments to cooling tower for supported equipment.
3. Design Calculations: Calculate requirements for selecting seismic restraints and wind restraints and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For certification required in "Quality Assurance" Article.

C. Field Test Reports: Include startup service reports.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.

B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Tool Kit:

1. A tool kit specially designed by cooling tower manufacturer for use in servicing cooling tower(s) furnished.
2. Special tools required to service components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Cooling Tower Tool Kit." Text size shall be at least 1 inch high.

4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.

B. Touchup Coating: 32-oz. container of paint coating used per cooling tower cell. Label outside of container with detailed description of coating to allow for procurement of a matching coating in the future.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI.

B. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

C. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.9 DELIVERY, STORAGE, AND HANDLING

A. Coordinate requirements for multi-piece assembly for shipment. Limit the number of separate pieces for field installation to as few as possible.

B. If factory assembly of multiple pieces is required for testing or other reasons, disassemble cooling tower into major assemblies as required by installation before packaging for shipment.

1. Clearly label each separate package with a unique designation and include assembly instructions for complete cooling tower.

C. Install seals on gear-drive assemblies to eliminate oil leakage during shipment if shipped with oil.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:

1. All components of cooling tower.
2. Fan assembly including fan, drive, and motor.
3. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ~~Baltimore Aircoil Company~~.
2. ~~EVAPCO, Inc~~.
3. Marley; a brand of SPX Cooling Technologies, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Cooling towers will be installed on CUP building roof on Structural Steel Frame designed by others. Roof is approximately 55 feet above grade and cooling tower steel mounting platform is approximately 12 feet above roof level. Cooling tower base will be nominal 67 feet above grade. Cooling tower location and force modifications will be taken into consideration in seismic withstand certification.

~~3. Provide Seismic Shaker Test Results / Certification that meet or exceeds site seismic requirements below;~~
~~a. Seismic Design Category C~~
~~b. Seismic Risk Category IV~~
~~c. Component Importance Factor = 1.5~~
~~d. SS=.1580; Fa=1.2~~
~~e. S1=.0850; Fv=1.7~~
~~f. SDS= .1264~~
~~g. SD1=.0963~~
~~h. Response Modification Factor, R= 3.0~~
~~i. Overstrength Factor (Omega) = 3.0~~
j. ~~Deflection Amp Factor (Cd) = 3.0~~

3. Provide Seismic Shaker Test Results / Certification that meet or exceeds site seismic requirements below;
a. Seismic Design Category C
b. Seismic Risk Category IV
c. Seismic Use Group III
d. Component Importance Factor, I_p = 1.5
e. Component Response Modification Factor, R_p= 3.0
f. Component Amplification Factor, a_p = 2.5

g. Short Term Spectral Response Acceleration Factor, ***S_{ds} = 12.64 % g***

h. Long Period Spectral Response Acceleration Factor, ***S_{d1} = 9.36% g***

i. *Structural Safety Factor* ***= 4.0***

B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1-2019.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. Include means and methods required to satisfy requirement even if not explicitly indicated.

E. Fan Vibration:

1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

A. Single or multiple cell crossflow design with airflow from two sides and induced-draft, top-mounted axial fan, FM approved for use without sprinklers with PVC fill and gravity distribution basin. Cooling towers designed for roof top mounting on structural steel frame designed by others. Provide Base Bid and Alternate Pricing Options as indicated. Owner may pick and choose the tower configuration and options if any that will constitute the final cooling tower configuration.

2.4 CASING AND FRAME

A. **BASE BID**

1. Casing Material: Galvanized steel, ASTM A653/A653M, G235 coating
2. Frame Material stainless steel, Grade 301 or Grade 304
3. Hardware: stainless steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Sealed watertight by continuous welds.

~~B. **BASE BID ADD ALTERNATE-1**~~

1. ~~Casing Material: Stainless steel, Grade 301, Grade 304, or Grade 316.~~
2. ~~Frame Material: stainless steel, Grade 301 stainless steel, Grade 304, or Grade 316.~~
3. ~~Hardware: stainless steel.~~
4. ~~Joints and Seams: Sealed watertight.~~
5. ~~Welded Connections: Sealed watertight by continuous welds.~~

2.5 COLLECTION BASIN

A. COLLECTION BASIN **-BASE BID**

1. Field-Constructed Collection Basin: Configure tower without a factory-assembled collection basin for installation and operation with a field-constructed collection basin.
2. Factory-Assembled Collection Basin:
   a. Material: Stainless steel, Grade 301, Grade 304 or Grade 316.
   b. Hardware: stainless steel.
   c. Joints and Seams: Sealed watertight.
   d. Welded Connections: Sealed watertight by continuous welds.
   e. Removable stainless-steel strainer with openings smaller than nozzle orifices.
   f. Overflow and drain connections.
   g. Makeup-water connection.
   h. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
   i. **Removable equalization flume plate between adjacent cells of multiple-cell towers is not allowed.**
   j. Bottom Equalizer connection for field-installed equalizer piping configured to mate to ASME B16.5, Class 150 flange.

B. **BASE BID ADD ALTERNATE-2**

1. Basin Sweeper Distribution and Return Piping and Nozzles:
   a) Piping shall be factory sized, designed and fitted for basin. Supply and return piping shall terminate at a single connection to cooling tower basin. All branch piping and pipe tie-downs/supports shall be provided. Configure piping and nozzles to minimize sediment from collecting in the collection basin. Provide separate basin sweeper filter / return drain. Positioned basin sweeper filter return drain in basin for effective debris removal. Provide removable stainless steel drain inlet strainer.
   b) Pipe Material: Internal basin piping shall be PVC or CPVC, Schedule 40 or heavier, treated with UV inhibitors and intended for continuous exposure to direct sunlight without degradation. Exterior basin sweeper connection piping shall be schedule 40 stainless steel NPS size.
   c) Basin Sweeper Filter Field Connections: Threaded or flanged depending on pipe size. Thread for sizes through 2” and flanged for larger sizes. Basin sweeper pipe penetrations stainless steel same material as collection basin seal welded watertight.
   d) Nozzle Material: Plastic, adjustable direction and spread, volume amplifying eductor type. Maximum nozzle pressure drop 10 psi.

e) Provide Basin Sweeper piping design calculations. Provide sweeper design supply flow rate, and supply/return differential head pressure at basin pipe connections. Provide recommended maximum/ minimum flow and pressure for basin sweeper system provided on BID FORM.

f) Basin sweeper piping design shall be based on nominal 1 gpm per square foot of tower basin area. Piping shall be sized for maximum head loss of of 3 ft/ 100 feet and maximum of 8 feet /sec. Nozzle pressure loss shall not exceed 10 psi. Basin Sweeper return inlet piping shall be one size larger than supply piping.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

A. **Vender may provide make up water assembly as noted in paragraph B or C below as Base Bid. Identify which BASE BID option is included in BASE BID on BID FORM.**

~~B. **BASE-BID:** Mechanically Operated, Collection Basin Water-Level Control with Electric/Electronic, Collection Basin Water-Level Monitor/ Alarm:~~

~~1. Manufacturer's standard adjustable, mechanical float assembly and valve.~~

~~a. Brass or bronze body with polypropylene float and adjustable brass lever arm.~~
~~b. Buna N rubber seat~~
~~c. Stainless steel trim.~~

~~2. Enclosures: NEMA 250, Type 4X.~~
~~3. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz~~
~~4. Water Level Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip for low- and high-level alarms to BMS system.~~
~~5. Water Level Electrode Probes: Adjustable length Stainless steel.~~
6. ~~Water Stilling Chamber: Corrosion-resistant material, FRP, PVC pipe, or 300 series Grade stainless steel pipe.~~

~~C. **BASE-BID:** Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve and level Monitor/ Alarm:~~

~~1. Enclosures: NEMA 250, Type 4X.~~
~~2. Sensor: Programmable Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve and low- and high-level alarms. Probes for :~~

~~a. High water level alarm.~~
~~b. High water level.~~
~~c. Low water level.~~
~~d. Low water level alarm.~~

~~3. Electrode Probes: Stainless steel.~~
~~4. Water Stilling Chamber: Corrosion-resistant material, FRP, PVC pipe, or 300 series Grade stainless steel pipe.~~

5. ~~Makeup-Water Valve:~~

   a. ~~Slow closing with stainless-steel body.~~
   b. ~~Actuator controlled and powered through level controller in response to water-level set point.~~
   c. ~~Actuator Enclosure: NEMA 250, Type 4X.~~
   d. ~~Fail Position: Last.~~
   e. ~~Action: Two position or modulating.~~

6. ~~Controls, relays , contactors and terminal strips for connection to BMS system Alarm / monitoring of~~

   a. ~~Makeup Valve Status Open/ Closed.~~
   b. ~~Low Water Level.~~
   c. ~~High Water Level.~~

7. ~~Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.~~

D. **BASE-BID ADD ALTERNATE-3:** Ultrasonic Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosure: NEMA 250, Type 4X.
2. Controller:

   a. Ultrasonic level sensor/transmitter with local display of measured value.
   b. Factory wired to terminal strip.
   c. Control make-up water valve in response to water-level set point.
   d. Adjustable level, alarm signal through relay closure for connection to control system.
   e. Signal continuous level indication through a 4- to 20-mA signal for connection to BMS control system.

3. Water Stilling Chamber: Corrosion-resistant material, FRP, PVC , or Stainless steel.
4. Makeup-Water Valve:

   a. Slow closing with stainless-steel body.
   b. Valve actuator controlled and powered through level controller in response to water-level set point.
   c. Actuator Enclosure: NEMA 250, Type 4X.
   d. Fail Position: Last.
   e. Action: Two position or modulating.

5. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN WATER HEATER- **BASE BID**

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Multiple bayonet style electric element immersion heaters. Heaters installed in threaded couplings or flanges on the side of the collection basin. Heaters sized to maintain basin water temperature at 40 deg F when outside air temperature is -20 deg F.

2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, Type 4X.
4. Programmable Solid-state controls with temperature RTD probes and relays factory wired to a terminal strips to control magnetic contactors to maintain collection basin water-temperature set point. Water-level / temperature probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Provide contacts and functionality for connection to BMS for:
    a. Real time basin temperature monitoring both locally and via BMS.
    b. Adjustable basin temperature set point, (factory set at 42 deg F).
    c. Basin heater test function.
        1. Provide means for locally and remotely initiating test
            a) Local and remote indication of heater status on/ failure.
    d. Low basin temperature alarm contacts.
    e. Adjustable basin water temperature dead band (factory set at 5 deg F).
6. Control-circuit transformer with primary and secondary side fuses.
7. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
8. Single-point, field-power connection to a lockable fused disconnect switch or circuit breaker and heater branch circuiting complying with NFPA 70.
9. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except connections to each electric basin heater shall be liquidtight conduit.
    a. Raceway shall be corrosion-resistant stainless steel or PVC coated steel.

2.8 GRAVITY WATER DISTRIBUTION BASIN- **BASE BID**

A. Design: Non-pressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated in item 7 below.

1. Material: 300 series stainless steel.
2. Location: Over each bank of fill with easily replaceable plastic spray nozzles mounted in bottom of distribution basin.
3. Fasteners: stainless steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Sealed watertight by continuous welds.
6. 50% flow reduction Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing and achieve proper operation while operating from 50% tower design flow to 100% tower cell design flow.
    a. Manufacturer has option to use individual nozzle cups in lieu of partitioning dams to achieve operation within flow range indicted above.
7. Removable Top Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable stainless-steel hardware. Panels reinforced to accommodate service personnel walking on the panels without resulting in permanent deflection and damage.

8. Single-Inlet, Field Pipe Connection: Provide each cooling tower cell with factory designed internal PVC pipe arranged to achieve balancing of flow within cooling tower cell without the need for additional balancing valves. Cooling tower cell single, bottom inlet field connection to be ASME B16.5, Class 150 flange.

2.9 FILL- **BASE BID**

A. Materials: FM approved PVC, with maximum flame-spread index of 25 or less according to ASTM E84. Fill UL listed for use without sprinklers.

B. Minimum Thickness: 15 mils, before forming.

C. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

D. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F.

E. Hardware: stainless steel.

2.10 DRIFT ELIMINATORS-**BASE BID**

A. Material: FM approved FRP or PVC; with maximum flame-spread index of 25 according to ASTM E84. UL listed for use without sprinklers

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Configuration: Multipass, designed and tested to reduce water carryover to less than or equal to 0.005 percent of tower cell design flow rate.

D. Location: Integral to or separate and removable from fill.

E. Hardware: stainless steel.

2.11 AIR INLET-**BASE BID**

A. Air-Intake Louvers:

1. Material: FRP or PVC.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
4. Location: Integral to or separate from fill.

B. Removable Air-Intake Screens:

1. ~~Stainless-steel~~ Galvanized Steel wire mesh with openings of size sufficient to not restrict airflow or impact performance.
2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

C. Hardware: stainless steel.

2.12 FAN AND DRIVE ASSEMBLY-**ALL BIDS**

A. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: Aluminum.
2. Hub Material: Aluminum or galvanized steel.
3. Blade Pitch: Field adjustable.
4. Fan Shaft: Stainless steel.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of 100,000 hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
7. Suitable for forward or reverse operation.

B. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

C. Gear Drive: Right angle, gear speed reducer, designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment and startup.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse. Able to operate throughout entire speed range from design speed indicated down to 10 of design speed.
5. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling.
6. Drive Shaft Material: Stainless steel and fitted with flexible couplings on both ends.
7. Drive Guards: Exposed shaft and couplings shall have guards according to OSHA regulations.
8. Extend oil fill, drain, and vent to outside of cooling tower casing using stainless-steel piping. Include oil-level sight glass.

D. Fan Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.

2. Description: NEMA MG 1, Design B, as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Totally enclosed and with epoxy or polyurethane finish.
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1, NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: One class lower than insulation rating.
9. Insulation: Class H.
10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Severe-Duty / Cooling Tower Duty Rating:
    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.
12. Motor Base: Adjustable, or other suitable provision.
13. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

E. Hardware: stainless steel.

2.13 AIR DISCHARGE

~~A. **BASE BID DEDUCT ALTERNATE-4 :** Low-Profile Fan Discharge Stack:~~

~~1. Manufacturer's standard low-profile design.~~
~~2. Material: Material to match casing Stainless steel.~~
~~3. Stack Termination: Wire-mesh, stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.~~
~~4. Provide OSHA approved handrail around fan discharge opening and warning signs indicating fan wire mesh screen weight limit.~~

B. **BASE BID:** Velocity Recovery Fan Discharge Stack:

1. Design: Tapered and expanded for velocity recovery and improved energy efficiency.
2. Material: FRP or material matching casing.

3. Stack Height: Fabricated to extend above fan deck at least 5 feet unless otherwise indicated.
4. Service Access: Fabricated of multiple segments to facilitate removal of fan and drive components from overhead.
5. Stack Termination: Wire-mesh, stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.

C. **ALL BIDS**: Hardware: stainless steel.

2.14 ELECTRICAL POWER-**ALL BIDS**

A. Provide cooling towers without variable frequency fan motor dives or fan motor starters. Variable frequency fan motor drives will be provide by others for field installation.

B. Provide cooling towers without disconnect switches for fan motors. Fan motor disconnect switches will be provide by others for field installation.

C.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

    a. Minimum Conduit Size: 0.75 inch.
    b. Materials: Corrosion resistant and constructed of stainless steel or PVC coated steel.
    c. Motor Termination: Liquidtight conduit, not to exceed 36 inches long.
    d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
    e. Wire:

        1. Copper, rated for 600-V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
        2. Minimum Wire Size: No. 12 AWG.
        3. Each circuit shall have a ground wire.
        4. Install wire in conduit.

D. Disconnect Switches: Basin Heaters-**BASE BID**

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, non-fused.
3. 600 V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 65,000 A.
5. Boxes, Condulets, and Enclosures: NEMA 250, Type 4 or Type 4X.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.

7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Disconnect switch shall have a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.
12. Horsepower rated.
13. Feed through or double lugged.
14. Installation shall comply with NFPA 70.
15. Wire, Conduit, and Enclosures:

    a. Minimum Conduit Size: 0.75 inch.
    b. Materials: Corrosion resistant and constructed of stainless steel or PVC coated steel.
    c. Motor Termination: Liquidtight conduit, not to exceed 36 inches long.
    d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
    e. Wire:

        1. Copper, rated for 600-V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
        2. Minimum Wire Size: No. 12 AWG.
        3. Each circuit shall have a ground wire.
        4. Install wire in conduit

2.15 CONTROLS-**ALL BIDS**

~~A. **BASE BID:** Vibration Switch: For each fan drive.~~

~~1. Enclosure: NEMA 250, Type 4 or Type 4X.~~
~~2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.~~
3. ~~Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.~~

B. **BASE BID ADD ALTERNATE-5:** Vibration Transmitter with Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4X.
2. Display: Local display of measured value, power, and alarm.
3. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.

    a. Cooling tower manufacturer shall select range that is suitable for cooling tower and recommend switch set point for proper operation and protection.

4. Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.
5. Switch:

    a. Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.
    b. Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.

6. Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible and where display is easily viewable.
7. Field Electrical Connection Requirements: 120 V, single phase, 60 Hz.

C. **BASE BID:** Gear-Drive, Oil-Level Switch: Low-oil-level monitoring warning switch for connection to control system.

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through control system.

D. **BASE BID:** Control Package:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. NEMA 250, Type 4 or Type 4X enclosure with removable internally mount backplate.
3. Control-circuit transformer with primary and secondary side fuses.
4. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
5. Collection basin level controller.
6. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Collection Basin Heater" Article.
7. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
8. Oil-level switch for each fan with a gear drive, complying with requirements in "Gear-Drive, Oil-Level Switch" Paragraph.
9. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
10. Cooling tower shall have hardware to enable control system to remotely monitor and display the following:

    a. Fan vibration alarm.
    b. Oil-level alarm.
    c. Collection basin high- and low-water-level alarms.
    d. Collection Basin Water heater test pass / failure.

2.16 SERVICE ACCESS

A. Doors: -**ALL BIDS**

1. Minimum of two doors located opposite each other in casing above cooling tower basin water overflow level. Doors shall be centered on cooling tower internal access platform / walkway. Each door shall be large enough for personnel to access / enter cooling tower and remove / service internal components including cooling tower fan motor.
2. Doors shall be hinged with handles operable from both sides of the door.
3. Door materials shall match casing.
4. Hinges and handles shall be stainless steel.
5. Doors shall open inward to the cooling tower to facilitate adjacent spacing of cooling tower cells.

B. Cooling Tower Fan Deck Floor and Handrail: -**ALL BIDS**

1. Factory furnish reinforced fan deck floor panels at fan deck level for cooling tower cells
2. Floor materials shall match adjacent cooling tower cell casing.
3. Fan deck floor shall fasten to and be supported by framing that is attached to cooling tower cells.
4. Frame shall be constructed of same materials as cooling tower frame.
5. Provide reinforced fan deck floor panels to fill gap between adjacent tower cells. Fan deck gap flooring shall attach to and match cooling tower structure and casing.
6. Provide handrail as indicated in handrail article below.
7. Provide latching swinging gates at handrail ladder access points.

B. Internal Platforms: Aluminum or stainless-steel bar grating. -**ALL BIDS**

1. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high-water level of the collection basin.
2. Provide elevated internal platforms with handrails accessible from collection basin platform via fixed vertical ladders to access the fan and gear reducer drive.
3. Provide latching swinging gates at handrail ladder access points.

C. Handrail: -**ALL BIDS**

1. Aluminum, or stainless steel complete with knee rail and toe board, around external, and internal platforms and around cooling tower fan deck and interconnecting walkways. Comply with 29 CFR .

D. Hardware: -**ALL BIDS**

1. All fasteners and hardware shall be stainless steel.

E. **BASE BID ADD ALTERNATE-6:** External Ladders with Safety Cages:

1. Aluminum, or stainless-steel fixed ladders with ladder extensions to access ~~collection basin level external platform from roof level and~~ tower fan deck from collection basin platform level.
2. Comply with 29 CFR 1910.27.

3. Cooling towers will be mounted on structural steel fabrication (by others) approximately 12 feet above roof level. One ladder shall extend down from collection basin level access platform to roof level and other ladder shall extend up from collection basin level platform to cooling tower fan deck. Two separate ladders are required.
4. Ladders shall have self-closing spring-operated safety gates. Fan deck ladder shall have safety cage.
5. Ladders shall be supported from cooling tower.

~~F. **BASE BID ADD ALTERNATE-7:** External Access Collection Basin Level Platform:~~

~~1. Cooling towers shall be arranged in adjacent cell / tower pairs linearly on the roof. A collector basin level access platform shall be provided at both ends of cooling tower linear lineup and in between adjacent cooling tower / cell pairs.~~
~~2. Access platforms shall be approximately 6 feet wide by 16 feet long centered on the cooling tower basin level access door and be supported from the cooling tower structural steel frame. Cooling tower access platforms between cooling towers shall be supported from both cooling towers platform is positioned between.~~
~~3. Provide OSHA approved handrails and toe boards around platforms. Provide gap for ladder access where ladders are provided. Provide handrails per handrail article.~~
~~4. The platforms shall be constructed of Aluminum, galvanized-steel or stainless-steel structural shapes and bar grating.~~
~~5. Cooling towers will be mounted on structural steel fabrication (by others) approximately 12 feet above roof level.~~

G. **BASE BID ADD ALTERNATE-8:** Additional Walkway / Platforms with Handrails Between Cooling Tower / Cell pairs at fan deck:

1. Provide fan deck level walkways with handrails and toe boards between cooling tower / cell pairs on roof. Walkways will be approximately 6 foot wide by 6 feet long.
2. Factory furnish reinforced fan deck floor panels between cooling tower cells for field installation.
3. Floor materials shall match adjacent cooling tower cell fan deck. Frame shall be constructed of same materials as cooling tower frame.
4. Fan deck floor shall fasten to and be supported by cooling tower framing.

2.17 HOISTING ASSEMBLY-**ALL BIDS**

A. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.

1. Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.
2. Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of 1.5.

3. Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load with safety factor.

B. Pedestal Base:

1. Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.
2. Position pedestal base at a location on cooling tower fan (top) deck for hoisting assembly coverage to fan, fan motor, and fan drive assembly.
3. Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.
4. Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.
5. Fasten pedestal base to cooling tower using threaded hardware.
6. Construct pedestal base of 300L series stainless steel.

C. Davit Arm:

1. Each cooling tower cell shall have a davit arm mounting base permanently attached.
2. Davit arm shall be a removable, adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.
3. Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base. Provide one davit arm for every other cooling tower.
4. Construct davit arm of 300L series stainless steel.

D. Winch:

1. Each davit arm shall have a hand-operated winch.
   a. Hand-operated winch with gear mechanism to limit force on handle to not more than 80 lb when lifting the heaviest component.

2. Coat winch body and exposed components with corrosion-resistant finish that is rated for outdoor duty in a highly corrosive environment and exposed to direct sunlight.
3. Winch cable shall be stainless steel and terminated with a stainless-steel hook and quick disconnecting mechanism. Cable length shall be at least 1.5 times actual length required for application.

E. Hardware: stainless steel.

F. Nameplate:

1. Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.
2. Letter size legible from a distance of 60 inches and not less than 1/2 inch.
3. Fasten nameplate at multiple points with stainless-steel rivets or screws.

2.18 CAPACITIES AND CHARACTERISTICS

BASE BID-1 ONE CELL 2,000 TON COOLING TOWER

A. Number / Capacity of Cooling Towers: **Six (6) / 2,000 tons each**

B. Number / Capacity of Cells per Cooling Tower: **One (1) / 2,000 tons each**

C. Air-Inlet Arrangement: **Two sides; opposite ends of Cooling Tower Cell width.**

D. Maximum Physical Dimensions:

1. Maximum Length: **29'-6"**
2. Maximum Width: **22'-6"**
3. Maximum Height to fan Deck: **26'-11 3/4"**
4. Fan Exhaust Recovery Stack Maximum Height: **5'-0"**
5. Maximum Space Between Tower pair: **6-inches**

E. Maximum Drift Loss: **0.005 % of design water flow.**

F. Waterside:

1. Design Water Flow per Cell: **6,000 gpm**.
2. Minimum Water Flow per Cell: ≤ **3,000 gpm or less**.
3. Inlet Water Pressure Drop: **≤ 23 feet static lift; 0 FT water distribution loss**.
4. Entering-Water Temperature: **95 deg F**.
5. Leaving-Water Temperature: **85 deg F.**
6. Single point bottom Flanged Inlet: **20" NPS**
7. Single point bottom Flanged Outlet: **24" NPS**
8. Water Basin Equalizer : Flanged Bottom or Side **20" NPS**
9. Makeup Water Inlet: Side or bottom inlet; **2" make up valve with controls**

G. Airside:

1. Entering-Air Wet-Bulb Temperature: **78 deg F**.
2. Altitude: **700 feet**.
3. Airflow per Cell: **Approximately 552,900 cfm**.
4. FAN TYPE: **Ultra Quiet Axial Fan; nominal 19 ft dia. 8 blades, 220 rpm**
5. Fan Static Pressure Regain Cowl; **Removable Segmented nominal 5 feet tall.**
6. Fill**:** **PVC; FM Approved for use without sprinklers.**

H. Fan Drive Assembly per Cell:

1. Type: **Direct or Gear**.
2. Gear Drive: **Heavy-Duty Right-angle reducer drive with resilient coupling. Designed for forward and reverse variable speed.**

3. Fan Motor:

a.	Type:	**Variable speed**.
b.	Motor Size per Cell**:**	**125 hp maximum.**
c.	Full-Load Ampacity:	**TBD.**
d.	Minimum Circuit Ampacity:	**TBD.**
e.	Maximum Overcurrent Protection:	**TBD.**
f.	Electrical Characteristics:	**480-VAC, 3 phase, 60 Hz**.

I. ASHRAE 90.1 Performance; **≥ 48 gpm/Hp**

J. Sound Pressure Level: **≤ 85 dB at 5 feet when measured according to CTI ATC 128.**

K. Collection Basin Heater:

1. Quantity: **Multiple electric stainless steel sheathed bayonet immersion heaters arranged to prevent collection basin from freezing.**
2. Basin Water Temperature: **40 deg F.**
3. Outdoor Ambient Temperature: **Minus 20 deg F**.
4. Capacity per Cell: **60 kW total, equally split across two to four heating elements.**
5. Full-Load Ampacity: **TBD.**
6. Minimum Circuit Ampacity: **TBD.**
7. Maximum Overcurrent Protection Device: **TBD.**
8. Electrical Characteristics: **480-V ac, 3 phase, 60 Hz**.

~~BASE BID-2- TWO CELL 2,000 TON COOLING TOWER~~

~~A. Number / Capacity of Cooling Towers: **Six (6) towers; 2,000 tons each**~~

~~B. Number / Capacity of Cells per Cooling Tower: **Two (2) 1,000 tons cells per cooling tower.**~~

~~C. Air-Inlet Arrangement: **Two sides; opposite ends of Cooling Tower Cell width.**~~

~~D. Maximum Physical Dimensions:~~

1. ~~Cell Maximum Length: **14’-0”**~~
2. ~~Cell Maximum Width: **22’-6”**~~
3. ~~Cell Maximum Height: **26’-11 3/4”**~~
4. ~~Nominal Tower Fan Deck Height: **24’-0”**~~
5. ~~Nominal Fan Exhaust Recovery Stack Height: **5’-0”**~~
6. ~~Maximum Space Between Cells of Two Cell Tower: **6 inches**~~
7. ~~Tower Nominal Length of Two Adjacent Cells: **28’-6”**~~
8. ~~Tower Nominal Width of Two Adjacent Cells: **22’-6”**~~
9. ~~Tower Maximum Height to Fan Deck : **19’-0”**~~

~~E. Maximum Drift Loss: **0.005 % of design water flow.**~~

F. Waterside:

1. Design Water Flow per Cell: **3,000 gpm**.
2. Minimum Water Flow per Cell: **≤ 1,500 gpm**.
3. Inlet Water Pressure Head Loss: **23 feet static lift; 0 FT water distribution loss**.
4. Entering-Water Temperature: **95 deg F**.
5. Leaving-Water Temperature: **85 deg F`.**
6. Single point bottom Flanged Inlet: **12" NPS**
7. Single point bottom Flanged Outlet: **18" NPS**
8. Water Basin Equalizer : Flanged Bottom or Side **16" NPS**
9. Makeup Water Inlet: Side or bottom NPS **2" NPS valve with controls**

G. Airside:

1. Entering-Air Wet-Bulb Temperature: **78 deg F**.
2. Altitude: **700 feet**.
3. Airflow per Cell: **Approximately 252,260 cfm**.
4. FAN TYPE: **Ultra Quiet Axial Fan; nominal 12 ft dia. 5 blades, 290 rpm**
5. Fan Static Pressure Regain Cowl; **Removable Segmented nominal 5 feet tall.**
6. Fill: **PVC; FM Approved for use without sprinklers.**

H. Fan Drive Assembly per Cell:

1. Type: **Direct or gear reducer type.**
2. Gear Drive: **Right angle reducer drive with resilient coupling. Forward and reverse variable speed. Heavy duty.**
3. Fan Motor:
   a. Type: **Variable speed**.
   b. Motor Size per Cell: **60 hp.**
   c. Full-Load Ampacity per Cell: **65 A**
   d. Minimum Circuit Ampacity per Cell: **TBD.**
   e. Maximum Overcurrent Protection Device: **TBD.**
   f. Electrical Characteristics: **480-VAC, 3 phase, 60 Hz**.

I. ASHRAE 90.1 Performance; **≥ 48 gpm/Hp**

J. Sound Pressure Level: **≤ 85 at 5 feet when measured according to CTI ATC 128.**

K. Collection Basin Heater:

1. Quantity; **Multiple electric stainless steel sheathed bayonet immersion. heaters arranged to prevent collection basin from freezing.**
2. Basin Water Temperature: **40 deg F.**

3. ~~Outdoor Ambient Temperature:~~ **~~Minus 20 deg F~~**.
4. ~~Capacity per Cell:~~ **~~30 kW total equally split across two to four heating elements.~~**
5. ~~Full-Load Ampacity:~~ **~~TBD.~~**
6. ~~Minimum Circuit Ampacity:~~ **~~TBD.~~**
7. ~~Maximum Overcurrent Protection:~~ **~~TBD.~~**
8. ~~Electrical Characteristics:~~ **~~480-VAC, 3 phase, 60 Hz~~**.

2.19 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."

1. Allow Owner access to place where cooling towers are being tested. Notify Owner in writing at least 30 days in advance of testing.
2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

B. Seismic Performance Testing: Shake table tested by an independent or a factory-certified laboratory to certify performance complies with seismic requirements indicated.

1. Allow Owner access to place where cooling towers are being tested. Notify Owner in writing at least 30 days in advance of testing.
2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
3. For seismically Pre-Certified cooling towers, provide Seismic Certification Certificate in -lieu of performance test. See section 2.2.A.

C. Factory Functional Tests:

1. Test collection and distribution basins after assembly and prove free of leaks.
2. Test factory-installed electric/electronic water-level controls for proper operation.
3. Test factory-installed electric basin heaters for proper operation.
4. Test factory-installed fan and drive assemblies for proper operation.
5. Test factory-installed control package for proper operation.
6. Test access doors to ensure smooth operation and proper fit.
7. Allow Owner access to place where cooling towers are being tested. Notify Owner in writing at least 30 days in advance of testing.
8. Submit report documenting tests performed and results within one week of test date.

D. Owner Travel Expenses:

1. Include cost associated with Owner travel expenses to witness testing. Total value attributed to travel expenses shall be clearly indicated on BID FORM.

2. Expenses shall include round-trip coach airfare, out of town hotel accommodations, out of town meals (breakfast, lunch, and dinner), out of town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for two Owner representative(s) with origin of Indianapolis, Indiana.

PART 3 - EXECUTION- **BY MECHANICAL CONTRACTOR**

3.1 EXAMINATION-PRE-INSTALLATION

A. Examine received cooling tower components before installation. Reject and replace cooling tower components that are damaged.

B. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting cooling tower performance, maintenance, and operation. Report any conditions that could affect cooling tower performance, maintenance or warranty to Construction Manager.

1. Determine final cooling tower locations before roughing-in for piping, controls, and electrical connections.
2. Verify sizes, locations, and anchoring attachments of structural-steel support structures.
3. Verify sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install cooling towers on support structure.

B. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Maintain clearances required by governing code.

F. Loose Components: Install components, devices and accessories furnished by manufacturer, with cooling tower, that are not factory mounted.

1. Loose components shall be installed by Contractor under supervision of manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Install drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains, to sanitary sewage system.

F. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

G. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to entering cooling tower connections with shutoff valve, motorized valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to leaving cooling tower connection with shutoff valve, motorized valve, thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

H. Equalizer Piping:

1. Piping requirements to match supply and return piping.
2. Connect an equalizer pipe, full size of cooling tower connection, between tower cells.

3. Connect to cooling tower with shutoff valve and drain connection with valve.
4. Make connections to cooling tower with a flange.

I. Basin Sweeper Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, flow meter, and drain connection with valve.
4. Make connections with a flange or union.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.

B. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

C. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

D. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

C. Connect control wiring between cooling tower control interface and control system for HVAC for remote monitoring and control of cooling towers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Install label at each termination indicating control equipment designation serving cooling tower and the I/O point designation for each control connection. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labeling and identifying products and installations.

3.6 FIELD TESTING PROVISIONS

A. Include provisions for cooling tower future field-performance testing complying with CTI ATC 105.

B. Include provisions in field piping for future field-performance testing complying with CTI ATC 105.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections: Comply with CTI ATC 105.

C. Cooling towers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 STARTUP SERVICE-

A. Engage a factory-authorized service representative to perform startup service.

B. Collaborate with water treatment professional to develop cooling tower passivation and anti-scaling treatment plan in accordance with cooling tower manufacturer’s requirements. Submit cooling tower passivation and anti-scaling plans to engineer and cooling tower manufacturer for approval prior to commencing.

C. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections prior to start-up.

D. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

    a. Clean entire unit including basins.
    b. Verify that accessories are properly installed.
    c. Verify clearances for airflow and for cooling tower servicing.
    d. Check for vibration isolation and structural support.
    e. Lubricate bearings.
    f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
    g. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
    h. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
    i. Check vibration switch setting. Verify operation.

j. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
k. Verify operation of basin heater and control.
l. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
m. Replace defective and malfunctioning units.

E. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

F. Prepare a written startup report that records the results of tests and inspections.

3.9 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

C. Adjust basin heater control for proper operating set point.

3.10 DEMONSTRATION

A. Provide factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

1. Video record the training sessions.
2. Instructor shall be factory trained and certified.
3. Perform not less than 8 hours of training.
4. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
5. Perform instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
6. Obtain Owner sign-off that training is complete.
7. Owner training shall be held at Project site.

END OF SECTION 236514.14

SECTION 237313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components, including the following:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Air filtration.
5. Dampers.
6. Air to Air Heat Recovery Units

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.

1. Withstand certification based ontest data.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

C. Startup service reports.

D. Sample Warranty: For manufacturer's warranty to comply with 1.7 below.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 year(s) from date of Substantial Completion inclusive of parts and labor.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 8-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.

F. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8 inch wg.

G. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Daikin Applied.
   2. Trane.
   3. YORK; brand of Johnson Controls International plc, Building Solutions North America.

2.3 UNIT CASINGS

A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:

   1. Material: Galvanized steel.
   2. Height: 6 inches.

C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

D. Double-Wall Construction:

   1. Outside Casing Wall:

      a. Material, Galvanized Steel: Minimum 18 gauge thick.
      b. Factory Finish: Provide manufacturer's standard finish.

   2. Inside Casing Wall:

      a. Material, Galvanized Steel: Solid, minimum 18 gauge thick.

E. Floor Plate:

   1. Material, Galvanized Steel: Minimum 18 gauge thick. Treadplate provided on floor for units exceeding 72” in height.

F. Casing Insulation:

1. Materials: Injected polyurethane foam insulation.
2. Casing Panel R-Value: Minimum R-13.
3. Insulation Thickness: 2 inches.
4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

G. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

H. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 8-inch wg.
2. For Unit Sections Downstream and Including Fans: 8-inch wg.

I. Doors, and Windows:

1. Doors:

a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow and against AHU pressure. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 72 inches.

2. Windows:
a. Construction: Fabricate windows in access panels and doors of double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
b. Size: Minimum 6 inches, square or round.
3. Locations and Applications:
a. Fan Section: Doors, with windows.
b. Coil Section: Doors, with windows.
c. Access Section: Doors.
4. Service Lights: LED vaporproof luminaire with individual switched junction box located outside unit.
a. Locations: Each section equipped with a window.
5. Convenience Outlets: One 20-A duplex GFCI receptacle near Fan section.

J. Condensate Drain Pans:

1. Construction:
   a. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

2. Drain Connection:

   a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple extending at least 2-1/2" beyond unit base rail.
   b. Minimum Connection Size: NPS 1.

3. Slope: Minimum slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches deep.
7. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.

   a. Turned, ground, and polished hot-rolled steel with keyway.

2. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

   a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

3. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
4. Plenum Fan Arrays: Contained as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of

multiple fans. Provide backdraft dampers at each fan to prevent short circuiting of flow if one fan is not operating.

5. Mounting: For internal vibration isolation and seismic control. Factory-mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 2 inch.
6. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

        1) Fabric Minimum Weight: 26 oz./sq. yd..
        2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
        3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.

C. Drive, Direct: Factory-mounted, direct drive.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure Type: Open, dripproof.

4. Efficiency: Premium Efficient motors as defined in NEMA MG 1.
5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

E. Provide ECM driven fans by Manufacturer where noted on schedule for small units requiring N+1 fan redundancy. VFD driven motors are allowed at Manufacturer preference if available in a 2x1 fan arrangement.

F. Comply with Section 262923 "Variable-Frequency Motor Controllers."

G. Variable-Frequency Motor Controller: Provided and installed by Division 26. Coordinate installation with Division 26.

2.5 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Heating Coils:

1. Hot-Water Coils: Continuous circuit, Self-draining.

a. Piping Connections: Threaded, same end of coil.
b. Tube Material: Copper.
c. Tube Diameter: ½ or 5/8 inches.
d. Tube Thickness: .025 inches.
e. Fin Type: Plate.
f. Fin Material: Aluminum.
g. Minimum Fin Thickness: 0.0060 inches.
h. Fin Spacing: Maximum 12 fins per inch.
i. Fin and Tube Joint: Mechanical bond.
j. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

k. Frames: Channel frame, 0.0625-inch-thick, galvanized steel.
l. Coil Working-Pressure Ratings: 300 psig, 325 deg F.
m. Coating: None.

C. Cooling Coils:

1. Chilled-Water Coil: Continuous circuit, Self-draining.

a. Piping Connections: Threaded, same end of coil.
b. Tube Material: Copper.
c. Tube Diameter: ½ or 5/8 inches.
d. Tube Thickness: .025 inches.
e. Fin Type: Plate.
f. Fin Material: Aluminum.
g. Minimum Fin Thickness: 0.0060 inches.
h. Fin Spacing: Maximum 12 fins per inch.
i. Fin and Tube Joint: Mechanical bond.
j. Headers:
1) Seamless copper tube with brazed joints, prime coated.

2) Provide insulated cover to conceal exposed outside casings of headers.

k. Frames: Channel frame, 0.0625-inch-thick, stainless steel.
l. Coatings: None.
m. Working-Pressure Ratings: 300 psig, 325 deg F.

2.6 AIR FILTRATION SECTION

1. Non-ionizing, polarized media electronic air cleaners: Operation:
   a. The Air Cleaner shall have an active electrostatic field that polarizes a dielectric media. It shall not ionize airborne particles or produce ozone.
   b. To minimize energy consumption, the AHU fan system has been designed for specific pressure drop through the Air Cleaning system. The fan system is designed for a maximum of 0.70" w.g when the filters are dirty.

2. Construction:
   a. Air Cleaner Modules:
      1) The Air Cleaner modules shall consist of four or six individual Air Cleaner Panels that are nominally 1” in thickness, arranged in V’s within the module.
      2) Each Air Cleaner module shall have disposable and recyclable media pads with a minimum of a class “2” fire rating. These shall have a positive seal in the overall module assembly to prevent bypass of un-filtered air.
   b. Filter Rack:
      1) The Air Cleaners will be arranged in pre-fabricated module assemblies nominally 12” or 18” in height, of varying widths up to 48”, and either 24” or 29.5” deep in direction of airflow.
      2) The number of modules and width shall be such that the face velocity thru the filter bank shall be no more than 550 fpm.
      3) The construction of the Air Cleaner frame and screens shall be aluminum, and the module side panels and attachment flanges shall be of galvanized steel.
   c. Air Handler Integration:
      1) The modules will be permanently mounted in the air handler and secured with vertical posts during factory installation in the Air Handler.
      2) The air handler will be configured so as to allow front or rear access for media changes of the filter assembly as shown on the air handler detail drawings. There must be at least 24” of space for service and media change-out.
      3) The Air Cleaner module bank will be flashed and sealed. The Air Cleaner modules and each component thereof must have a positive seal where necessary to prevent bypass of unfiltered air.

3. Electrical:
   a. The high voltage powerheads on the Air Cleaner shall require 24 volts AC input and have a 9.5kV DC output. The powerheads must be fully potted and connected in parallel.
   b. Control Panel:
      1) The 24VAC power supply must be a UL or CSA certified transformer, class “2” type, which shall permit one side of the secondary output (24V) to be attached to electrical ground.
      2) A filter Minihelic gauge shall be installed in the Unit Control Panel that provides a direct readout and a 4-20mA output for the building automation system.
   c. Electrical Connection:
      1) The Air Handler manufacturer shall provide a fully operational filter section for factory connection and field electrical tie-in.
      2) All 24VAC electrical and control wiring integral to the Air Cleaner modules and Control Panel, including the access door interlocks, are to be provided by the Air Cleaner manufacturer for connection in the factory.
      3) All line voltage connections and wiring are the responsibility of the contractor.

4. Construction and Start-up: If the air handler is operated during construction, the contractor shall protect the Air Cleaner bank using roll or other filter media with a minimum of MERV 8 rating. These should be removed after 30 days from initial startup.

2.7 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B 09.

2.8 DAMPERS

A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."

B. Face-and-Bypass Dampers: Opposed-blade, extruded-aluminum dampers with zinc-plated steel operating rods rotating in stainless steel or nylon bearings mounted in a single extruded-aluminum frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

D. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
    b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
    c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
    e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): 24 V dc.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: Minus 22 to plus 122 deg F.
14. Run Time: 120 seconds.

2.9 AIR-TO-AIR ENERGY RECOVERY UNITS

A. Heat Wheels:

1. Casing:

    a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard finish.
    b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
    c. Casing seals on periphery of rotor, on duct divider, and on purge section.
    d. Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
2. Rotor - Aluminum: Segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
3. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with an L-10 of 400,000 hours.
4. Controls:

    a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
    b. Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
    c. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
    d. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain [**exhaust temperature above freezing and**]air differential temperature above set point. Provide

maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.

e. Pilot-Light Indicator: Display rotor rotation and speed.

2.10 Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.

B. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.

C. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

D. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

E. Air Cleaner Certifications: The Air Cleaner shall have been tested and meet UL Standard 867 and CSA Standard C22.2 No. 187-M19986 for electrostatic Air Cleaners.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply

with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1, ASTM B88, CPVC pipe. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system.
5. Verify that bearings and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
7. Comb coil fins for parallel orientation.
8. Contractor shall remove the roll or other filter media used to protect the Non-ionizing, polarized media electronic air cleaners during construction operations. Media shall only be removed upon contractor full demobilization from the project site.
9. Verify that manual and automatic volume control and fire dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan airflow and pressure performance.

3.7 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.8 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313.16

SECTION 238123.11 – SMALL CAPACITY (6 TONS (21 KW) AND SMALLER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes floor-mounted, computer-room air conditioners of 6 tons and smaller.

1.3 DEFINITIONS

A. COP: Coefficient of performance.

B. EER: Energy efficiency ratio.

C. SCR: Silicon controlled rectifier.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Product Data: For energy performance.
2. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For computer-room air conditioners.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for computer-room air conditioners, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters: One set(s) of filters for each unit.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Compu-Aire, Inc.
2. Above Air
3. Liebert; Vertiv Holdings Co.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 MANUFACTURED UNITS

A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

B. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch-thick duct liner.

1. Floor Stand: Welded tubular steel, 24 inch high, with adjustable legs and vibration isolation pads with turning vanes mounted within the stand.
2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Unit with powder-coated insulated return air distribution plenum.

C. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.

D. Refrigeration System:

1. Compressor: Scroll, variable capacity, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit:

a. Low-pressure switch.
b. Manually reset, high-pressure switch.
c. Thermal-expansion valve with external equalizer.
d. Sight glass with moisture indicator.
e. Service shutoff valves.
f. Charging valves.
g. Hot-gas bypass.
h. Refrigerant charge.

3. Refrigerant: R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
5. Refrigerant line sets.
6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.

a. Mount stainless-steel drain pan complying with ASHRAE 62.1 under coil assembly.

7. Remote Air-Cooled Refrigerant Condenser:

a. Integral, copper-tube aluminum-fin coil.
b. Condenser with surge protection device (SPD) and locking disconnect in the enclosed electrical panel section.
c. Fans: Direct-drive, variable-speed propeller type.

8. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

E. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating two-way control valve and flow switch.

1. Cooling Medium: Water.
2. Mount stainless-steel drain pan complying with ASHRAE 62.1 under coil assembly.

F. Hot-Water Reheat: Copper-tube, aluminum-fin coil with two-way, modulating control valve, and cleanable Y-strainer.

G. Filter: 4-inch- thick, disposable, pleated, glass-fiber media.

1. Initial Resistance: .1 inches wg.
2. Recommended Final Resistance: 1 inches wg.

H. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

I. Disconnect Switch: Locking disconnect with handle accessible with the door closed.

J. Control System:

1. Microprocessor unit-mounted panel.
2. Fan contactor.
3. Control transformer with circuit breaker.
4. Solid-state temperature- and humidity-control modules.
5. Humidity contactor.
6. Time-delay relay.
7. Smoke sensor.
8. High-temperature thermostat.
9. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:

    a. Adjust set points.
    b. CRAC unit start, stop, and operating status.
    c. Data inquiry, including supply and room-air temperature and humidity.
    d. Hydronic and refrigerant valve positions.
    e. Filter pressure drop with estimated time to replacement.
    f.

K. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

D. Computer-Room Air-Conditioner Mounting: Install using restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 Air-Cooled Refrigerant Condenser Mounting: Install using restrained spring isolators on concrete base. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Hot-Water Heating Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in inlet and outlet piping to heating coils.

E. Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Provide shutoff valves in water inlet and outlet piping on water-cooled units.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123.11

SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Blower coil units and accessories.
2. Fan coil units and accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.

1. Withstand certification based on test data.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish one full set of spare filters for each filter installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion inclusive of parts and labor.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fan coil units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor =1.0
4. Component Response Modification Factor = 2.5.
5. Seismic Design Category C, Risk/Occupancy Category IV

2.3 BLOWER COIL UNITS (BCU series tag)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Price.
3. Trane Inc.
4. Johnson Controls International plc, Building Solutions North America.

B. Fan Coil Unit Configurations: Row split.

1. Number of Heating Coils: Two-pipe heating system connection. See schedules for heating coil quantities.
2. Number of Cooling Coils: One with two-pipe system cooling system connection.

C. Coil Section Insulation: 1-inch- thick, closed-cell foam or foil faced fiberglass.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Main and Auxiliary Drain Pans: Stainless Steel. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.

E. Chassis: Galvanized steel.

F. Cabinet: Galvanized Steel.

G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

1. MERV Rating: 8 when tested according to ASHRAE 52.2.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

I. Fan and Motor Board:

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: ECM, 0-10VDC control.
3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Control devices are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Blower Coil Units shall be provided with a pre-wired single point controls connection for field provided thermostat from the temperature controls contractor. Control box shall include 24V transformer and disconnect switch.

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

2.4 FAN COIL UNITS (FCU series tag)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck Fan Corporation.
   2. Price.
   3. Trane Inc.
   4. Johnson Controls International plc, Building Solutions North America.

B. Fan Coil Unit Configurations: Row split cabinet style vertical or horizontal as per schedules.

   1. Number of Heating Coils: Two-pipe heating system connection. See schedules for heating coil quantities.
   2. Number of Cooling Coils: Two-pipe system cooling system connection. See schedules for heating coil quantities.

C. Coil Section Insulation: 1-inch- thick, closed cell foam or foil faced fiberglass.

   1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Main and Auxiliary Drain Pans: Plastic or Stainless Steel. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.

E. Chassis: Galvanized steel, with baked enamel finish.

F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
   1. MERV Rating: 13 when tested according to ASHRAE 52.2.

G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

H. Direct-Driven Fans: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.

I. Motors: ECM, 0-10 VDC control.

J. Control devices are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Fan Coil Units shall be provided with a pre-wired single point controls connection for field provided thermostat from the temperature controls contractor. Control box shall include 24V transformer and disconnect switch.

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 238219

SECTION 238239.16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes propeller unit heaters with hot-water coils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

1. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.

5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Submit certification that propeller unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Engineered Air.
2. Modine.
3. Sterling HVAC Products.
4. Trane.

2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 2021.

D. Comply with UL 823.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Seismic Performance: Propeller unit heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 HOUSINGS

A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Discharge Louver: Adjustable fin diffuser.

2.5 COILS

A. General Coil Requirements: Test and rate hot-water propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Steel tube, minimum 0.049-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with manual air vent. Test for leaks to 600 psig underwater.

2.6 FAN AND MOTOR

A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.7 CONTROLS

A. Control Devices:
1. Wall-mounted thermostat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:

1. Section 232113 "Hydronic Piping."
2. Section 232116 "Hydronic Piping Specialties."

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Comply with safety requirements in UL 1995.

E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

END OF SECTION 238239.16

SECTION 260010 - SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Supplemental requirements generally applicable to the Work specified in Division 26. This Section is also referenced by related Work specified in other Divisions.

B. Related Requirements:

1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. 8P8C: An 8-position 8-contact modular jack.
2. A: Ampere, unit of electrical current.
3. AC or ac: Alternating current.
4. AFCI: Arc-fault circuit interrupter.
5. AIC: Ampere interrupting capacity.
6. AL, Al, or ALUM: Aluminum.
7. ASD: Adjustable-speed drive.
8. ATS: Automatic transfer switch.
9. AWG: American wire gauge; see ASTM B258.
10. BAS: Building automation system.
11. BIL: Basic impulse insulation level.
12. BIM: Building information modeling.
13. CAD: Computer-aided design or drafting.
14. CATV: Community antenna television.
15. CB: Circuit breaker.
16. cd: Candela, the SI fundamental unit of luminous intensity.
17. CO/ALR: Copper-aluminum, revised.
18. COPS: Critical operations power system.
19. CU or Cu: Copper.
20. CU-AL or AL-CU: Copper-aluminum.
21. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
22. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.

23. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
24. dBm: Decibel absolute power with respect to 1 mW.
25. DC or dc: Direct current.
26. DCOA: Designated critical operations area.
27. DDC: Direct digital control (HVAC).
28. EES: Essential Electrical Systems
29. EGC: Equipment grounding conductor.
30. ELV: Extra-low voltage.
31. EMF: Electromotive force.
32. EMI: Electromagnetic interference.
33. EPM: Electrical preventive maintenance.
34. EPS: Emergency power supply.
35. EPSS: Emergency power supply system.
36. ESS: Energy storage system.
37. EV: Electric vehicle.
38. EVPE: Electric vehicle power export equipment.
39. EVSE: Electric vehicle supply equipment.
40. fc: Footcandle, an internationally recognized unit of illuminance equal to one lumen per square foot or 10.76 lx. The simplified conversion 1 fc = 10 lx in the Specifications is common practice and considered adequate precision for building construction activities. When there are conflicts, lux is the primary unit; footcandle is specified for convenience.
41. FLC: Full-load current.
42. ft: Foot.
43. GEC: Grounding electrode conductor.
44. GFCI: Ground-fault circuit interrupter.
45. GFPE: Ground-fault protection of equipment.
46. GND: Ground.
47. HACR: Heating, air conditioning, and refrigeration.
48. HDPE: High-density polyethylene.
49. HID: High-Intensity-Discharge - Lighting.
50. H.I.D.: High-Impedance-Differential – Relay Protection
51. HMI: Human Machine Interface, (also called OIT).
52. HP or hp: Horsepower.
53. HVAC: Heating, ventilating, and air conditioning.
54. Hz: Hertz.
55. IBT: Intersystem bonding termination.
56. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
57. IP: Ingress protection rating (enclosures); Internet protocol (communications).
58. IR: Infrared.
59. IS: Intrinsically safe.
60. IT&R: Inspecting, testing, and repair.
61. ITE: Information technology equipment.
62. kAIC: Kiloampere interrupting capacity.
63. kcmil or MCM: One thousand circular mils.
64. kV: Kilovolt.
65. kVA: Kilovolt-ampere.
66. kVAr or kVAR: Kilovolt-ampere reactive.

67. kW: Kilowatt.
68. kWh: Kilowatt-hour.
69. LAN: Local area network.
70. lb: Pound (weight).
71. lbf: Pound (force).
72. LCD: Liquid-crystal display.
73. LCDI: Leakage-current detector-interrupter.
74. LED: Light-emitting diode.
75. Li-ion: Lithium-ion.
76. lm: Lumen, the SI derived unit of luminous flux.
77. LNG: Liquefied natural gas.
78. LP-Gas: Liquefied petroleum gas.
79. LRC: Locked-rotor current.
80. LV: Low voltage.
81. lx: Lux, the SI derived unit of illuminance equal to one lumen per square meter.
82. m: Meter.
83. MCC: Motor-control center.
84. MDC: Modular data center.
85. MG set: Motor-generator set.
86. MIDI: Musical instrument digital interface.
87. MLO: Main lugs only.
88. MV: Medium voltage.
89. MVA: Megavolt-ampere.
90. mW: Milliwatt.
91. MW: Megawatt.
92. MWh: Megawatt-hour.
93. NC: Normally closed.
94. Ni-Cd: Nickel-cadmium.
95. Ni-MH: Nickel-metal hydride.
96. NIU: Network interface unit.
97. NO: Normally open.
98. NPT: National (American) standard pipe taper.
99. OCPD: Overcurrent protective device.
100. OIT: Operator Interface Terminal (see HMI).
101. ONT: Optical network terminal.
102. PC: Personal computer.
103. PCS: Power conversion system.
104. PCU: Power-conditioning unit.
105. PF or pf: Power factor.
106. PHEV: Plug-in hybrid electric vehicle.
107. PLC: Programmable logic controller.
108. PLFA: Power-limited fire alarm.
109. PoE: Power over Ethernet.
110. PV: Photovoltaic.
111. PVC: Polyvinyl chloride.
112. pW: Picowatt.
113. RFI: (electrical) Radio-frequency interference; (contract) Request for interpretation.
114. RMS or rms: Root-mean-square.

115. RPM or rpm: Revolutions per minute.
116. SCADA: Supervisory control and data acquisition.
117. SCR: Silicon-controlled rectifier.
118. SPD: Surge protective device.
119. sq.: Square.
120. SWD: Switching duty.
121. TCP/IP: Transmission control protocol/Internet protocol.
122. TEFC: Totally enclosed fan-cooled.
123. TR: Tamper resistant.
124. TVSS: Transient voltage surge suppressor.
125. UL: (standards) Underwriters Laboratories, Inc.; (product categories) UL, LLC.
126. UPS: Uninterruptible power supply.
127. USB: Universal serial bus.
128. UV: Ultraviolet.
129. V: Volt, unit of electromotive force.
130. V(ac): Volt, alternating current.
131. V(dc): Volt, direct current.
132. VA: Volt-ampere, unit of complex electrical power.
133. VAR: Volt-ampere reactive, unit of reactive electrical power.
134. VFC: Variable-frequency controller.
135. VOM: Volt-ohm-multimeter.
136. VPN: Virtual private network.
137. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
138. W: Watt, unit of real electrical power.
139. Wh: Watt-hour, unit of electrical energy usage.
140. WPT: Wireless power transfer.
141. WPTE: Wireless power transfer equipment.
142. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-A: Aluminum electrical metallic tubing.
3. EMT-S: Steel electrical metallic tubing.
4. EMT-SS: Stainless steel electrical metallic tubing.
5. ENT: Electrical nonmetallic tubing.
6. EPEC: Electrical HDPE underground conduit.
7. EPEC-40: Schedule 40 electrical HDPE underground conduit.
8. EPEC-80: Schedule 80 electrical HDPE underground conduit.
9. EPEC-A: Type A electrical HDPE underground conduit.
10. EPEC-B: Type B electrical HDPE underground conduit.
11. ERMC: Electrical rigid metal conduit.
12. ERMC-A: Aluminum electrical rigid metal conduit.
13. ERMC-S: Steel electrical rigid metal conduit.
14. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
15. ERMC-S-PVC: PVC-coated-steel electrical rigid metal conduit.
16. ERMC-SS: Stainless steel electrical rigid metal conduit.
17. FMC: Flexible metal conduit.

18. FMC-A: Aluminum flexible metal conduit.
19. FMC-S: Steel flexible metal conduit.
20. FMT: Steel flexible metallic tubing.
21. FNMC: Flexible nonmetallic conduit. See "LFNC."
22. HDPE: See EPEC.
23. IMC: Steel electrical intermediate metal conduit.
24. LFMC: Liquidtight flexible metal conduit.
25. LFMC-A: Aluminum liquidtight flexible metal conduit.
26. LFMC-S: Steel liquidtight flexible metal conduit.
27. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
28. LFNC: Liquidtight flexible nonmetallic conduit.
29. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
30. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
31. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
32. PVC: Rigid PVC conduit.
33. PVC-40: Schedule 40 rigid PVC conduit.
34. PVC-80: Schedule 80 rigid PVC Conduit.
35. PVC-A: Type A rigid PVC concrete-encased conduit.
36. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
37. RGS: See ERMC-S-G.
38. RMC: See ERMC.
39. RTRC: Reinforced thermosetting resin conduit.
40. RTRC-AG: Low-halogen, aboveground reinforced thermosetting resin conduit.
41. RTRC-AG-HW: Heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
42. RTRC-AG-SW: Standard wall, low-halogen, aboveground reinforced thermosetting resin conduit.
43. RTRC-AG-XW: Extra heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
44. RTRC-BG: Low-halogen, belowground reinforced thermosetting resin conduit.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:

1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CL2: Class 2 cable.
7. CL2P: Class 2 plenum cable.
8. CL2R: Class 2 riser cable.
9. CL2X: Class 2 cable, limited use.
10. CL3: Class 3 cable.
11. CL3P: Class 3 plenum cable.
12. CL3R: Class 3 riser cable.
13. CL3X: Class 3 cable, limited use.
14. CM: Communications general-purpose cable.
15. CMG: Communications general-purpose cable.

16. CMP: Communications plenum cable.
17. CMR: Communications riser cable.
18. CMX: Communications cable, limited use.
19. DG: Distributed generation cable.
20. FC: Flat cable.
21. FCC: Flat conductor cable.
22. FPL: Power-limited fire-alarm cable.
23. FPLP: Power-limited fire-alarm plenum cable.
24. FPLR: Power-limited fire-alarm riser cable.
25. IGS: Integrated gas spacer cable.
26. ITC: Instrumentation tray cable.
27. ITC-ER: Instrumentation tray cable, exposed run.
28. MC: Metal-clad cable.
29. MC-HL: Metal-clad cable, hazardous location.
30. MI: Mineral-insulated, metal-sheathed cable.
31. MTW: (machine tool wiring) Moisture-, heat-, and oil-resistant thermoplastic cable.
32. MV: Medium-voltage cable.
33. NM: Nonmetallic sheathed cable.
34. NMC: Nonmetallic sheathed cable with corrosion-resistant nonmetallic jacket.
35. NMS: Nonmetallic sheathed cable with signaling, data, and communications conductors, plus power or control conductors.
36. NPLF: Non-power-limited fire-alarm circuit cable.
37. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
38. NPLFR: Non-power-limited fire-alarm circuit riser cable.
39. NUCC: Nonmetallic underground conduit with conductors.
40. OFC: Conductive optical fiber general-purpose cable.
41. OFCG: Conductive optical fiber general-purpose cable.
42. OFCP: Conductive optical fiber plenum cable.
43. OFCR: Conductive optical fiber riser cable.
44. OFN: Nonconductive optical fiber general-purpose cable.
45. OFNG: Nonconductive optical fiber general-purpose cable.
46. OFNP: Nonconductive optical fiber plenum cable.
47. OFNR: Nonconductive optical fiber riser cable.
48. PLTC: Power-limited tray cable.
49. PLTC-ER: Power-limited tray cable, exposed run.
50. PV: Photovoltaic cable.
51. RHH: (high heat) Thermoset rubber, heat-resistant cable.
52. RHW: Thermoset rubber, moisture-resistant cable.
53. SA: Silicone rubber cable.
54. SE: Service-entrance cable.
55. SIS: Thermoset cable for switchboard and switchgear wiring.
56. TBS: Thermoplastic cable with outer braid.
57. TC: Tray cable.
58. TC-ER: Tray cable, exposed run.
59. TC-ER-HL: Tray cable, exposed run, hazardous location.
60. THW: Thermoplastic, heat- and moisture-resistant cable.
61. THHN: Thermoplastic, heat-resistant cable with nylon jacket outer sheath.
62. THHW: Thermoplastic, heat- and moisture-resistant cable.

63. THWN: Thermoplastic, moisture- and heat-resistant cable with nylon jacket outer sheath.
64. TW: Thermoplastic, moisture-resistant cable.
65. UF: Underground feeder and branch-circuit cable.
66. USE: Underground service-entrance cable.
67. XHH: Cross-linked polyethylene, heat-resistant cable.
68. XHHW: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Abbreviations and Acronyms for Electrical Flexible Cord Types:

1. SEO: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
2. SEOW: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
3. SEOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
4. SEOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
5. SJEO: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
6. SJEOW: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
7. SJEOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
8. SJEOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
9. SJO: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp locations.
10. SJOW: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
11. SJOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp locations.
12. SJOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
13. SJTO: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
14. SJTOW: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
15. SJTOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.

16. SJTOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
17. SO: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp locations.
18. SOW: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
19. SOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp locations.
20. SOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
21. STO: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
22. STOW: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.
23. STOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
24. STOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.

E. Definitions:

1. 8-Position 8-Contact (8P8C) Modular Jack: An unkeyed jack with up to eight contacts commonly used to terminate twisted-pair and multiconductor Ethernet cable. Also called a "TIA-1096 miniature 8-position series jack" (8PSJ), or an "IEC 8877 8-pole jack."
2. Basic Impulse Insulation Level (BIL): Reference insulation level expressed in impulse crest voltage with a standard wave not longer than 1.5 times 50 microseconds and 1.5 times 40 microseconds.
3. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
4. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.
5. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
6. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable, or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
7. Designated Seismic System: A system component that requires design in accordance with Ch. 13 of ASCE/SEI 7 and for which the Component Importance Factor is greater than 1.0.

8. Direct Buried: Installed underground without encasement in concrete or other protective material.
9. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosures covers include the following:

    a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
    b. Concrete Box: A box intended for use in poured concrete.
    c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
    d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
    e. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
    f. Device Box: A box with provisions for mounting a wiring device directly to the box.
    g. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
    h. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
    i. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
    j. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
    k. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
    l. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
    m. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
    n. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
    o. Raised-Floor Box: A floor box intended for use in raised floors.

p. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
q. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
r. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
s. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
t. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

10. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that are designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety to human life.
11. Essential Electrical Systems: (healthcare facilities) Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system.
12. Fault Limited: Providing or being served by a source of electrical power that is limited to not more than 100 W when tested in accordance with UL 62368-1.

    a. The term "fault limited" is intended to encompass most Class 1, 2, and 3 power-limited sources complying with Article 725 of NFPA 70; Class ES1 and ES2 electrical energy sources that are Class PS1 electrical power sources (e.g., USB); and Class ES3 electrical energy sources that are Class PS1 and PS2 electrical power sources (e.g., PoE). See UL 62368-1 for discussion of classes of electrical energy sources and classes of electrical power sources.

13. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
14. Jacket: A continuous nonmetallic outer covering for conductors or cables.
15. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.
16. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.

17. Multi-Outlet Assembly: A type of surface, flush, or freestanding raceway designed to hold conductors, receptacles, and switches, assembled in the field or at the factory.
18. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
19. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
20. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
21. Sheath: A continuous metallic covering for conductors or cables.
22. UL Category Control Number (CCN): An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
23. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

    a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
    b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
    c. Extra-Low Voltage (ELV): Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V(ac rms), 42 V(ac peak), or 60 V(dc).
    d. Low Voltage (LV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
    e. Medium Voltage (MV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated about 1 kV but not exceeding 69 kV.

24. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.

1.3 COORDINATION

A. Provide temporary electrical service or power in accordance with requirements specified in Division 01. To include coordination for Utility metered transformer for construction power. Provide transformer secondary circuits and distribution panelboards.

1.4 PREINSTALLATION MEETINGS

A. Electrical Preconstruction Conference: Schedule conference with Owner Project Representative and Project Team, not later than 10 days after notice to proceed. Agenda topics include, but are not limited to, the following:

1. Electrical installation schedule.
2. Status of power system studies.
3. Value analysis proposals and requests for substitution of electrical equipment.
4. Utility work coordination and class of service requests.
5. Commissioning activities.
6. Sustainability activities, including Measurement and Verification Plan.

1.5 SEQUENCING

A. Conduct and submit results of power system studies using field measurements and Shop Drawings for electrical equipment. Submit breaker and relay settings for review prior to field setting and testing.

1.6 SCHEDULING

A. Project Schedule

1.7 ACTION SUBMITTALS

A. Coordination Drawings for Large Equipment Indoor Installations:

1. Location plan, drawn to scale, showing heavy equipment or truck access paths to loading dock or other freight access into building. Indicate available width and height of doors or openings.

1.8 INFORMATIONAL SUBMITTALS

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:

1. Submission of power system studies.
2. Submission of specified coordination drawings.
3. Submission of action submittals specified in Division 26.
4. Orders placed for major electrical equipment.
5. Arrival of major electrical equipment on-site.
6. Preinstallation meetings specified in Division 26.
7. Utility service outages.
8. Utility service inspection and activation.
9. Mockup reviews.

10. Closing of walls and ceilings containing electrical Work.
11. System startup, testing, and commissioning activities for major electrical equipment.
12. System startup, testing, and commissioning activities for emergency lighting.
13. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
14. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
15. Requests for special inspections.
16. Requests for inspections by authorities having jurisdiction.

1.9 CLOSEOUT SUBMITTALS

A. Facility EPM Program Binders:

1. Complete Set: On approved online or cloud solution and USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
2. Reproducible hardcopy on archival quality, 28 lb (105 GSM), acid-free, bond paper.

B. Operation and Maintenance Data:

1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device listed below:

    a. Main Service Switchgear (MSS)
    b. 125V DC Station Battery System for MSS
    c. Paralleling Switchgear (PS)
    d. Generator Paralleling Controls Cabinets
    e. SCADA System
    f. Medium Voltage Automatic Transfer Switchgear (MV-ATS)
    g. 125V DC Station Battery System for PS and MV-ATS
    h. Generators
    i. MV Load Bank
    j. ESS-CUP Unit Substation
    k. Mech1 and Mech2 Unit Substations
    l. CH1 and CH2 Unit Substations
    m. Switchboards
    n. Panelboards
    o. Light Fixture – Inverter System
    p. Light Fixture – Controls
    q. Heat Trace Controls
    r. Uninterruptable Power Supplies (UPS)
    s. Load Bank and Controller

2. Include the following information:

    a. Manufacturer's operating specifications.

b. User's guides for software and hardware.
c. Schedule of maintenance material items recommended to be stored at Project site.
d. Detailed instructions covering operation under both normal and abnormal conditions.
e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
f. List of load-current and overload-relay heaters with related motor nameplate data.
g. List of lamp types and photoelectric relays used on Project, with ANSI and manufacturers' codes.
h. Manufacturer's instructions for setting field-adjustable components.
i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
k. Exterior pole inspection and repair procedures.

C. Software and Firmware Operational Documentation: Provide software and firmware operational documentation in Facility EPM Program Binders, including the following:

1. Software operating and upgrade manuals.
2. Names, versions, and website addresses for locations of installed software.
3. Device address list.
4. Printout of software application and graphic screens.
5. Testing and adjusting of panic and emergency power features.
6. For lighting controls, include the following:

a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
b. Operation of adjustable zone controls.

D. Software:

1. Program Software Backup: Provide username and password for approved online or cloud solution and USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
2. Provide to Owner upgrades and unrestricted licenses for installed and backup software, including operating systems and programming tools required for operation and maintenance.

1.10 QUALIFICATIONS

A. Qualified Regional Manufacturer: Manufacturer, possessing qualifications specified in Section 014000 "Quality Requirements," that maintains a service center capable of providing training, parts, and emergency on-site repairs to Project site with response time less than eight hours.

B. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including seismic- and wind-load modeling and analysis.

C. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical power system modeling and analysis of electrical safety in accordance with NFPA 70E.

D. Lighting Professional Engineer: Professional engineer possessing active qualifications in accordance with Section 014000 "Quality Requirements" and the following:

1. Expertise in electrical engineering, lighting design, and structural requirements for exterior poles and standards.
2. Lighting Certified (LC) Professional by the National Council on Qualifications for the Lighting Professions (NCQLP).

E. EPM Specialist: Recognized experts possessing the following qualifications in accordance with Section 014000 "Quality Requirements" and NFPA 70B:

1. Technical Competence: Person should, by education, training, and experience, be well-rounded in all aspects of electrical maintenance.
2. Administrative and Supervisory Skills: Person should be skilled in planning and development of long-range objectives to achieve specific results and should be able to command respect and solicit cooperation of persons involved in EPM Program development.

F. Welder: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," with training and certification in accordance with AWS D1.1/D1.1M and AWS D1.2/D1.2M.

G. Medium-Voltage Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with training and manufacturer certification to install, splice, and terminate medium-voltage cable.

H. Medium-Voltage Duct Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with installation of medium-voltage duct banks.

I. Medium-Voltage Equipment Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with hazards and safety requirements associated with installation and operation of medium-voltage equipment in accordance with electrical utility service provider requirements.

1. Medium-voltage equipment Installer must be approved by AES for the Main Switchgear Utility Metering Cabinets.

J. Electrical Power Monitoring Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by manufacturer prior to starting installation.

K. EVSE Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by EVSE manufacturer prior to starting installation.

L. Generator Set Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by generator set manufacturer prior to starting installation.

M. Lightning Protection System Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired UL-Listed Installer, UL Category Control Number OWAY, credentials or unexpired LPI Master Installer credentials prior to starting installation.

N. Power Quality Specialist: Recognized experts possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction, and able to present unexpired NICET Level 4 credentials with documented experience in power quality testing for installations similar in complexity to this Project.

O. Medium-Voltage and Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

P. Power-Limited Electrical Testing Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site power-limited testing supervisor must have BICSI Registered Communications Distribution Designer certification and documented training and experience with testing power-limited equipment in accordance with NETA testing standards.

Q. Structural Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing structural concrete, seismic controls, and wind-load controls.

R. Luminaire Photometric Testing Laboratory: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" accredited under the NVLAP for Energy Efficient Lighting Products, and complying with applicable IES testing standards.

S. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and

experience with testing and inspecting lighting installations in accordance with IES LM-5.

1.11 FIELD CONDITIONS

A. Modeling, analysis, product selection, installation, and quality control for Work specified in Division 26 must comply with requirements specified in Section 260011 "Facility Performance Requirements for Electrical."

B. Service Conditions for Electrical Power Equipment: Besides conditions specified in Section 260011 "Facility Performance Requirements for Electrical," specified electrical power equipment must be suitable for operation under service conditions specified as usual service conditions in applicable NEMA PB series, IEEE C37 series, and IEEE C57 series standards, except for the following:

PART 2 - PRODUCTS

2.1 SUBSTITUTION LIMITATIONS FOR ELECTRICAL EQUIPMENT

A. Substitution requests for electrical equipment will be entertained under the following conditions:

1. Substitution requests may be submitted for consideration prior to the Electrical Preconstruction Conference if accompanied by value analysis data indicating that substitution will comply with Project performance requirements while significantly increasing value for Owner throughout life of facility.
2. Substitution requests may be submitted for consideration concurrently with submission of power system study reports when those reports indicate that substitution is necessary for safety of maintenance personnel and facility occupants.
3. Contractor is responsible for sequencing and scheduling power system studies and electrical equipment procurement. After the Electrical Preconstruction Conference, insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.

2.2 FACILITY ELECTRICAL PREVENTIVE MAINTENANCE (EPM) PROGRAM BINDERS

A. Description: Set of binders containing operation and maintenance data for facility's electrical equipment that was compiled during analysis of installed electrical Work for Facility EPM Program development.

B. Applicable Standards:

1. Regulatory Requirements: Comply with recommendations in NFPA 70B.
2. General Characteristics:

a. Volume 1 - Introduction:

1) Summarize how Facility EPM Program Analysis was performed, how data were collected, and how volumes are organized.
2) Describe Facility EPM Program and provide recommended policies and procedures for implementing the program and keeping it current.
3) Provide place for Owner to identify contact information for employees responsible for implementing and maintaining Facility EPM Program.

b. Volume 2 - Facility Safety, Hazards Awareness, and Emergency Procedures:

1) Include training requirements for employees and contractors.
2) Include list of known facility hazards impacting IT&R activities.
3) Include approval and permitting procedures for IT&R activities.
4) Include incident emergency response procedures.
5) Include emergency shutdown procedures.
6) Include electrical disaster recovery procedures.

c. Volume 3 - Operating Procedures for Electrical Equipment and Controls:

1) Main Service Switchgear
2) Paralleling Switchgear
3) MV-ATS Switchgear
4) Generators
5) DC Station Battery Systems
6) Mech Substation and Switchgear
7) Chiller Substation and Switchgear
8) Emergency Substation and Switchgear
9) Distribution Switchboards
10) Distribution Panelboards
11) Automatic Transfer Switches
12) SCADA System
13) UPS System
14) Lighting System
15) Heat Trace Systems

d. Volume 4 - Facility Diagrams and Schedules:

1) Include single-line diagrams.
2) Include grounding and bonding diagrams.
3) Include essential wiring diagrams.
4) Include system automation diagrams (SCADA, BMS, lighting, HVAC, etc.).
5) Include records of switchgear, switchboard, and panelboard schedules.
6) Include time-current curves for overcurrent protective devices.
7) Include list of load-current and overload-relay heaters with related motor nameplate data.

e. Volume 5 - Inventory of Facility Equipment Using Electrical Power:

1) Include simplified floor plans showing equipment locations.
2) Identify critical equipment (electrical or otherwise).
3) Include identifying designations and nameplate data.
4) Include warranty and maintenance contract information.

f. Volume 6 - Inventory of Facility Tools, Supplies, and Personnel Protective Equipment:

1) Include schedules of maintenance material items recommended to be stored at facility.
2) Include list of lamp types and photoelectric relays used in facility with ANSI and manufacturers' codes.
3) Include calibration and servicing data for each item.

g. Volume 7 - Inspection, Testing, and Repair (IT&R) Plan:

1) Include tables showing frequency of activities for each item.
2) Include annual schedule with activities mapped to specific days of the year.
3) Include exterior pole inspection and repair procedures.

h. Volume 8 - Inspection, Testing, and Repair (IT&R) Forms:

1) Include Manufacturer Start-Up and Testing Forms.
2) Include Commissioning Agent Forms.

i. Volume 9 - Inspection, Testing, and Repair (IT&R) Procedures:

1) Include Manufacturer Start-Up and Testing Procedures.
2) Include Commissioning Agent Procedures.

j. Volume 10 - Spare Parts List:

1) Include list of all parts required to perform IT&R procedures.
2) Identify quantities of which parts are recommended to be stored on-site.
3) Include source contact information and budget cost for each item.

k. Volume 11 - Construction Project Closeout Record Documentation:

1) Include records of power system studies and photometric studies.
2) Include records of risk assessment studies.
3) Include records of electrical system startup and commissioning activities.
4) Include records of baseline inspections and tests.
5) Include records of baseline infrared photographs with normal light photographs showing the location, direction, angle, and conditions necessary for reproducing each infrared photograph.

6) Include records of baseline settings for adjustable equipment and devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. <**Insert Project requirements**>.

B. Preinstallation Testing:

1. <**Insert Project requirements**>.

C. Evaluation and Assessment:

1. <**Insert Project requirements**>.

3.2 PREPARATION

A. Protection of In-Place Conditions:

1. <**Insert Project requirements**>.

3.3 DEVELOPMENT OF FACILITY EPM PROGRAM

A. Facility EPM Program must be developed by qualified EPM specialist.

B. Conduct Facility EPM Program analysis in accordance with NFPA 70B recommendations.

C. Compile operation and maintenance data from Facility EPM Program analysis and submit Facility EPM Program Binders.

3.4 INSTALLATION OF ELECTRICAL WORK

A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of Work specified in Division 26. Consult Architect for resolution of conflicting requirements.

3.5 SYSTEM STARTUP

A. Commissioning Activities:

1. <**Insert requirements**>.

3.6 FIELD QUALITY CONTROL

A. Administrant for Medium-Voltage and Low-Voltage Electrical Tests and Inspections:

1. Engage qualified medium-voltage and low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

B. Administrant for Power-Limited Electrical Tests and Inspections:

1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

C. Administrant for Field Tests and Inspections of Lighting Installations:

1. Administer and perform tests and inspections with assistance of factory-authorized service representative.

3.7 CLEANING

A. Waste Management:

1. <**Insert requirements for electrical and electronics waste disposal**>.

3.8 CLOSEOUT ACTIVITIES

A. Demonstration:

1. With assistance from factory-authorized service representatives, demonstrate to Owner's maintenance and clerical personnel and building occupants how to operate the following systems and equipment:

a. Lighting control devices specified in Section 260923 "Lighting Control Devices."
b. Electronic metering and billing software specified in Section 262713 "Electricity Metering."
c. Switchboards.
d. MV Switchgear.

e. MV Paralleling Gear.
f. MV-ATS Gear.
g. Unit Substations with Switchgear Secondary.
h. Unit Substations with MV Switchgear Secondary.
i. Generators.
j. UPS.
k. Heat Trace Systems.

2. Allow Owner to record demonstrations.

B. Training:

1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:

a. How to implement Facility EPM Program.
b. How to operate normal and emergency electrical systems, including justifications for, and limitations of, protective device settings recommended in study report specified in Section 260573.16 "Coordination Studies."
c. Electrical power safety fundamentals refresher including arc-flash hazard safety features of electrical power distribution equipment in facility, interpreting arc-flash warning labels, selecting appropriate personal protective equipment, and understanding significance of findings documented in study report specified in Section 260573.19 "Arc-Flash Hazard Analysis."
d. How to adjust, operate, and maintain devices specified in Section 260923 "Lighting Control Devices."
e. How to adjust, operate, and maintain equipment specified in Section 261116.11 "Secondary Unit Substations with Switchgear Secondary."
f. How to adjust, operate, and maintain equipment specified in Section 261116.12 "Secondary Unit Substations with MV Switchgear Secondary."
g. How to adjust, operate, and maintain equipment specified in Section 261326 "Medium-Voltage Metal-Clad Switchgear."
h. How to adjust, operate, and maintain equipment specified in Section 263600 "MV-ATS Switchgear."
i. How to adjust, operate, and maintain equipment specified in Section 262327 "Paralleling Switchgear."
j. How to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units specified in Section 262413 "Switchboards."
k. How to adjust, operate, and maintain control modules specified in Section 262416.16 "Electronically Operated Circuit-Breaker Panelboards."
l. How to adjust, operate, and maintain equipment specified in Section 262923 "Variable-Frequency Motor Controllers."

m. How to adjust, operate, and maintain controllers, remote alarm panels, and to use and reprogram microprocessor-based controls within this equipment specified in Section 262933 "Controllers for Fire Pump Drivers."
n. How to adjust, operate, and maintain equipment specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."
o. How to adjust, operate, and maintain equipment specified in Section 263323.11 "Central Battery Equipment for Emergency Lighting."
p. How to adjust, operate, and maintain equipment specified in Section 263343 "Battery Chargers."
q. How to adjust, operate, and maintain equipment specified in Section 263353 "Static Uninterruptible Power Supply."
r. How to adjust, operate, and maintain equipment specified in Section 263533 "Power Factor Correction Equipment."
s. How to adjust, operate, and maintain transfer switches and related equipment, including ground-fault protection system, specified in Section 263600 "Transfer Switches."
t. How to adjust, operate, and maintain devices specified in Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits."

2. Allow Owner to record training sessions.

END OF SECTION 260010

SECTION 260011 - FACILITY PERFORMANCE REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Field conditions and other facility performance requirements applicable to Work specified in Division 26.

1.2 FIELD CONDITIONS

A. Seismic Hazard Design Loads:

1. Unless otherwise indicated on Contract Documents, specified Work must withstand seismic hazard design loads determined in accordance with requirements specified in this Section, adjusted for installed elevation above or below grade.

a. The term "withstand" means "unit must remain in place without separation of parts from unit when subjected to specified seismic hazard design loads and unit must be fully operational after seismic event."

2. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7 edition or other seismic calculation method required by authorities having jurisdiction. Where "ASCE/SEI 7" is used throughout this Section, it must be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the Section Text.

a. Data indicated below to be determined by Delegated Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
b. Building Occupancy Category: IV.
c. Building Risk Category: IV.
d. Building Site Classification: C.

3. Calculation Factors, ASCE/SEI 7-16, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-16 unless otherwise indicated.

a. Horizontal Seismic Design Force F_p: Value must be calculated by Delegated Design Contractor using Equation 13.3-1. Factors below must be obtained for this calculation:

1) Spectral Acceleration (S_{DS}): based on ASCE/SEI 7-16 Section 11.4.5. Value applies to all components on Project.
2) Component Amplification Factor (a_p): Based on ASCE/SEI 7-16 Section 13.6.1. See Drawing Schedule for each component.
3) Component Importance Factor (I_p): Based on ASCE/SEI 7-16 Section 13.1.3. See Drawing Schedule for each component.
4) Component Operating Weight (W_p): For each component. Obtain by Delegated Design Contractor from each component submittal.
5) Component Response Modification Factor (R_p): Based on ASCE/SEI 7-16, Table 13.6-1. See Drawing Schedule for each component.
6) Height in Structure of Point of Attachment of Component for Base (z): Determine from Project Drawings for each component by Delegated Design Contractor. For items at or below the base, "z" must be taken as zero.
7) Average Roof Height of Structure for Base (h): Determine from Project Drawings by Delegated Design Contractor.

b. Vertical Seismic Design Force: Calculated by Delegated Design Contractor using method explained in ASCE/SEI 7-16, Paragraph 13.3.1.2.

c. Seismic Relative Displacement (D_{pl}): Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.2. Factors below must be obtained for this calculation:

1) Relative Seismic Displacement that Each Component Must Be Designed to Accommodate (D_p): Calculated by Delegated Design Contractor in accordance with ASCE/SEI 7-16, Paragraph 13.3.2.
2) Structure Importance Factor (I_e): Based on ASCE/SEI 7-16 Section 11.5.1. Value applies to all components on Project.
3) Deflection at Building Level x of Structure A (δ_{xA}): Based on ASCE/SEI 7-16, Equation 12.8-15. See Drawing Schedule for each component.
4) Deflection at Building Level y of Structure A (δ_{yA}): Based on ASCE/SEI 7-16, Equation 12.8-15. See Drawing Schedule for each component.
5) Deflection at Building Level y of Structure B (δ_{yB}): Based on ASCE/SEI 7-16, Equation 12.8-15. See Drawing Schedule for each component.
6) Height of Level x to Which Upper Connection Point Is Attached (h_x): Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
7) Height of Level y to Which Upper Connection Point Is Attached (h_y): Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
8) Allowable Story Drift for Structure A (Δ_{aA}): Based on ASCE/SEI 7-16, Equation 12.12-1. See Drawing Schedule for each component.
9) Allowable Story Drift for Structure B (Δ_{aB}): Based on ASCE/SEI 7-16, Equation 12.12-1. See Drawing Schedule for each component.

10) Story Height Used in the Definition of the Allowable Drift Δ_a (h_{sx}): based on ASCE/SEI 7-16, Equation 12.12-1. See Drawings Schedules for each component.

d. Component Fundamental Period (T_p): Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.3. Factors below must be obtained for this calculation:

1) Component Operating Weight (W_p): Determined by Contractor from Project Drawings and manufacturer's data.
2) Gravitational Acceleration (g): **32.17 ft./s^2 (9.81 m/s^2)**.
3) Combined Stiffness of the Component, Supports, and Attachments (K_p): Determined by delegated design seismic engineer.

B. Altitude:

1. Sea level to **1500 ft. (450 m)**.

C. Ambient Temperature:

1. 80 deg F.

D. Temperature Variation: Allow for thermal movements from the following differential temperatures:

1. Ambient Temperature Differential: 120 deg F (67 deg C).
2. Material Surface Temperature Differential: 180 deg F (100 deg C)
3. Ground Surface Temperature Differential to 10 ft. (3 m) Depth:.

E. Ground Water:
1. Assume ground-water level is 36 inch (900 mm) below ground surface unless a higher water table is indicated on Drawings.

F. Acoustical Performance Conditions:

1. See Architectural Sheets.

G. Hazardous Material Environmental Conditions:

1. Fuel Storage.

2. Fuel Pumping Room.

3. Fuel Day Tank Room.

H. Corrosive Environmental Conditions:

1. Bulk Brine Storage.

2. Water Softener Room.

3. Chemical Treatment Room.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 260011

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, front end specifications, and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. LEED Requirements.
2. Definitions.
3. General electrical requirements.
4. Electrical coordination and installation.
5. Temporary electricity.
6. Submittals.
7. Delivery, storage, and handling.
8. Cutting, patching, damage, and mutilation.
9. System startup.
10. Warranty.
11. Firestopping.

1.3 LEED REQUIREMENTS

A. All work and materials performed under this section shall comply with the LEED Submittals sections.

1.4 DEFINITIONS

A. Furnish: Supply but do not install the specific item, component, equipment, system, etc.

B. Install: Place in position, make connections and adjust for use of the specific item, component, equipment, system, etc.

C. Provide: Furnish and install the specific item, component, equipment, system, etc.

D. Equipment: A general term, including material, fittings, devices, appliances, luminaires, apparatus, machinery, etc. used as part of or in the connection with an electrical installation, per NEC.

E. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces, immediately below roof, space above ceilings, unexcavated spaces, crawlspaces, and tunnels.

F. Concealed, Inaccessible, Interior Installations: Concealed from view and protected from physical contact by building occupants. Rendered inaccessible by the structure of finish of the building, per NEC. Examples include above hard ceilings and in chases not behind an access panel.

G. Concealed, Accessible, Interior Installations: Concealed from view and protected from physical contact by building occupants. Accessible via the structure of the finish of the building, per NEC. Examples include above lay-in ceilings and behind access panels in chases.

H. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and from physical contact by building occupants but subject to outdoor ambient temperatures. Examples include duct banks and equipment within an underground vault or manhole.

I. Exposed, Interior Installations: Exposed to view indoors, and accessible. Examples include mechanical equipment rooms.

J. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

K. Rough-In: Suitable raceway terminated at each end in a suitable box or with a bushing and containing a pull string.

L. Work: Labor, installation, materials, equipment, systems, etc. required to complete a portion of the project scope.

M. NFPA 70 (National Electrical Code - NEC): Currently adopted NFPA 70 code with all amendments as adopted by the state or local authority having jurisdiction.

1.5 GENERAL ELECTRICAL REQUIREMENTS

A. Provide all required labor, material, equipment, and Contractor’s services necessary to complete the electrical installation required in full conformity with the Contract Documents and as required to meet all current codes and ordinances including all requirements of the Occupational Safety and Health Act latest edition.

B. This Contractor shall review the complete set of drawings and specifications and include work from other divisions that affect his work.

C. Perform all work to conform to or exceed the minimum requirements of the current edition of the National Electrical Code, NECA and all federal, state, local and municipal codes and ordinances. Work shown on the drawings or in the specifications that exceed the minimum requirements of the NFPA 70 or other regulations shall be

installed as indicated. Comply with the directions of all properly appointed authorities having jurisdiction.

D. OSHA: Contractor, Sub-Contractor, and all those working at the job site shall adhere to all requirements of the Occupational Safety and Health Act latest edition.

E. Drawings are diagrammatical in nature and do not show every required miscellaneous detail, support, fitting, etc. Drawings shall not be scaled for purposes of equipment installation. All measurements shall be verified to ensure equipment, raceways, devices, luminaires, etc. are installed in a neat and workmanlike manner. Furnish and install all materials required for a complete and operational electrical system.

F. Obtain all permits, licenses, certificates and pay for all fees necessary to complete the electrical installation unless otherwise noted in the front end specifications or Division 01.

G. Field verify all conditions and dimensions as they pertain to the intent of the drawings and specifications. Contractor shall bring to the attention of the Engineer any discrepancies discovered prior to the commencement of any work affected by or related to such discrepancy. Contractor shall be responsible for all costs associated with or caused by that contractor's failure to comply with this requirement.

H. Provide all disconnects, starters, outlets, receptacles, wiring, raceway, pathways, etc. required to properly connect all equipment indicated in the Construction Documents to be furnished and installed by other Trades and/or by the Owner, or furnished by other Trades and/or the Owner for installation by this Contractor. Verify all requirements with approved submittals prior to rough-in and installation.

I. Rough-in requirements for all equipment to be connected may not be shown on the drawings. Contractor shall verify all electrical requirements with the other Trades and/or the Owner furnishing the equipment, and with the manufacturer of the equipment.

J. The Engineer reserves the right to make changes of the locations of all receptacles, switches, equipment, etc. up to the time of rough-in or setting of equipment without additional cost to the project.

K. Field verify exact location of electrical equipment including lighting fixtures, fire alarm devices, security system devices, receptacles, etc. in rooms containing exposed ductwork, piping, etc. and rearrange as required by the Engineer.

L. All materials shall be new and shall be Underwriters Laboratories (UL) labeled conforming to NEMA Standards and all applicable codes unless otherwise noted.

M. Manufacturer Qualifications: Company specializing in manufacturing products with not less than three years of documented experience.

N. Workmanship: As a minimum requirement, NECA ”Good Workmanship in Electrical Construction” shall be followed along with any additional requirements as described in the specifications and on the drawings.

O. To help prevent sound transmission from one space to another, do not install recessed equipment and devices back to back in the same wall.

P. Provide all cutting, patching, and replacement of materials for electrical work in accordance with all appropriate Divisions of Specifications.

Q. Paint surface mounted or otherwise exposed conduit, raceway, boxes and other unfinished electrical materials in finished spaces. Paint to match surfaces to which they are attached to or color as selected by Architect.

R. All finish painting shall be in accordance with and provided under Division 09 and paid for by this Contractor.

S. Provide access panels and doors for electrical items that are required to remain accessible that are installed in non-accessible spaces. Access doors and panels are specified in Division 08.

T. Contractor shall examine architectural drawings to verify wall thickness for proper recessing depth for all flush installed equipment, devices, etc. Any instance of inadequate depth shall be brought to the attention of the architect and engineer prior to Bids or provided for by this contractor.

U. Copies of Documents at Project Site: Maintain at the project site a copy of each referenced document that prescribes execution requirements (drawings, specifications, submittals, addendums, etc.).

1.6 VERIFICATION

A. Contractor shall visit the project site to verify existing conditions relative to the project scope.

B. Work shown on the drawings as "existing" is assumed to be in place and suitable for modifications and additions as indicated on the drawings. This contractor shall field verify these items prior to installation and shall make all necessary provisions required for proper installation as required by the drawings and specifications. Contractor shall submit questions in reference to existing conditions in writing to the architect/engineer.

1.7 COORDINATION

A. Contractor shall coordinate with all other Trades to assure proper timing and installation of materials and equipment to meet the sequence of construction. Contractor shall also coordinate with other trades to ensure installation is within intended space requirements, meets code requirements, and does not result in any conflicts. Minor

field installation deviations from the drawings are acceptable to ensure proper installation and that all code requirements are met.

B. Before performing any work, review the drawings and confirm that the electrical work does not interfere with clearance required for beams, foundations, columns, pilasters, partitions, ductwork, plumbing, fire protection, etc. Where interferences develop after installation of equipment, this contractor shall make changes requested by the Engineer as required to provide proper clearances at the expense of this Contractor.

C. Coordinate arrangement, mounting, and support of electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping installed at required slope.
   4. To allow raceways, cables, wireways, cable trays, busways, etc. to be clear of obstructions and of the working and access space of other equipment.

D. Coordinate location of access panels and doors for electrical items that are behind finished surfaces concealed in locations that will remain inaccessible in the future.

E. For equipment requiring connections by other trades; provide approved submittals to the appropriate trade. Approved submittals are to include all information required by the other trade.

F. Coordinate all training sessions with the Owner and Engineer. All training sessions shall be performed and scheduled at the Owner's convenience. Quantity of training sessions and length of each session shall be as specified in the technical specification sections.

1.8 TEMPORARY ELECTRICITY

A. Provide temporary power and lighting for the progression of work by all Trades as required by Division 01.

1.9 SERVICE CONTINUITY

A. Continuity:
   1. Service continuity to existing equipment shall be addressed in the following manner:
      a. Maintain service continuity to all existing loads that are to remain by modifying and/or extending conduit and wiring as required. Field verification of existing conduit runs and circuitry is to be done as required. This is applicable to receptacles, overhead power drops, disconnects, lighting, wiring and connections to equipment.

1.10 SUBMITTALS

A. Provide submittals for products in Division 26, 27, and 28.

B. Shop drawing submittals shall comply with the following:
   1. Organize each submittal by specification section and it shall include all manufactured items.
   2. Include wiring diagrams, riser diagrams, etc. showing the quantity and types of cables, raceway required for systems such as Lighting Control, Sound Systems, Access Control, etc. Drawings will be returned for completion if the locations and routing of the devices and cables are not shown. Delays in the construction schedules due to incomplete drawings shall be the responsibility of this Contractor.

C. Submit record drawings in accordance with Division 01

D. Where new electrical equipment, devices, cabling, etc. specified or noted on the drawings are obsolete, provide replacements that meet or exceed all options and accessories necessary for its function. Submit replacement for approval.

E. Contractor shall verify recessed depths for luminaires against catalog reference material prior to providing submittals for review.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle all material and equipment in accordance with the manufacturer's recommendation unless specifically otherwise noted.

B. Store all materials and equipment off-site unless approved by the Engineer. Materials and equipment stored on-site shall be stored in a climate controlled indoor space and so as not to interfere with construction or facilities in use by Owner.

C. Damaged material and equipment shall not be furnished or installed.

1.12 CUTTING, PATCHING, DAMAGE, AND MUTILATION

A. The General Contractor is responsible for all cutting and patching indicated on the Architectural Drawings related to installation or removal of work by the Electrical Contractor. All required cutting and patching may not be shown. Any additional cutting and patching required for electrical work, which is not indicated on the Architectural Drawings, is the responsibility of the Electrical Contractor.

B. Properly patch and repair cuts made into or penetration made through fire rated walls, floors, and ceilings to maintain their proper fire rating.

C. Roof openings required by this Contractor that are not shown on the Architectural or Structural Drawings shall be provided by the Division 07 Contractor and paid for by this Contractor.

D. All undue or untimely damage or mutilation of masonry, plaster and other finished surfaces around conduit, equipment, etc., created by this Contractor shall be repaired by the proper Contractor and paid for by this Contractor.

E. This Contractor shall be responsible for damage to or mutilation of the work of the other Contractors or to the building and its contents caused by equipment installed or work performed by this Contractor.

F. The finish of any item that has been marred, scratched or damaged in any way by this Contractor shall be repaired and repainted at the expense of this Contractor, and to the satisfaction of the Engineer.

1.13 BASIC ELECTRICAL REQUIREMENTS

A. All electrical systems shall be designed and specified as “fully-rated” systems. “Series-rated” systems are not acceptable.

1.14 DATA GATHERING BY ELECTRICAL CONTRACTOR

A. The following scope of work shall be performed by the E.C.
   1. E.C. shall provide documentation showing exact feeder lengths for all new feeders. Include conductor type and size as well as insulation type.
   2. E.C. shall provide documentation showing the exact overcurrent protection devices installed and the settings and ratings.
   3. E.C. shall provide and Install the Arc Flash labels.
      a. As determined by the Arc Flash study; label information and format will be given to the E.C.

1.15 SYSTEM START-UP

A. Perform tests on all systems and each piece of equipment as required by applicable codes and/or as specified.

B. Clean all equipment of construction debris and dust prior to demonstration to Owner.

C. All work shall include start-up of all systems, demonstrating each system to the Owner, and training the Owner in the proper operation of each system. Furnish operational and maintenance instructions.

1.16 WARRANTY

A. In addition to the warranty required under the provisions of front end, Division 0 and 1 specifications, provide additional warranty for work and materials for the time periods indicated under individual Sections of the Specifications or for a duration of one (1) year from the date of final acceptance by the owner or substantial completion, whichever is longer. Manufacturer product Warranties and Guaranties that exceed the minimum requirements of the Contract Documents shall be adhered to.

B. Contractor shall correct, repair, and/or replace any deficiencies of any part of the installation to the satisfaction of the Owner and Engineer for the duration of the warranty/guarantee period.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to top of unit for wall-mounted items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with the project documents.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

3.2 FIRESTOPPING

A. The following compliment Division 7 Firestopping.

B. Provide firestopping to raceway and cable penetrations of fire-rated floor, ceilings, partitions and wall assemblies for electrical installations to maintain fire-resistance rating of assembly. Fire stopping material will be as follow:
   1. Use only firestop products that have been UL 1479 or ASTM E 814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.

2. Pre-installed firestop devices for use with noncombustible and combustible pipes (closed and open systems), conduit, and/or cable bundles penetrating concrete floors and/or gypsum walls, the following products are acceptable:

    a. Hilti Cast-In Place Firestop Device (CP 680-P) or equal for use with combustible penetrants.
    b. Hilti Cast-In Place Firestop Device (CP 680-M) or equal for use with noncombustible penetrants.
    c. Hilti Firestop Speed Sleeve (CP 653) or equal for use with cable penetrations.
    d. Hilti Firestop Drop-In Device (CFS-DID) or equal for use with noncombustible and combustible penetrants.

3. Sealants, foams or caulking materials for use with non-combustible items including rigid steel conduit (GRC, IMC) and electrical metallic tubing (EMT), the following products are acceptable:

    a. Hilti Intumescent Firestop Sealant (FS-ONE) or equal.
    b. Hilti Fire Foam (CP 620) or equal.
    c. Hilti Flexible Firestop Sealant (CP 606) or equal.

4. Intumescent sealants, caulking materials for use with combustible items (penetrants consumed by high heat and flame) including PVC jacketed, flexible cable or cable bundles, and plastic pipe, the following products are acceptable:

    a. Hilti Intumescent Firestop Sealant (FS-ONE) or equal.

5. Foams, intumescent sealants, or caulking materials for use with flexible cable or cable bundles, the following products are acceptable:

    a. Hilti Intumescent Firestop Sealant (FS-ONE) or equal.
    b. Hilti Fire Foam (CP 620) or equal.
    c. Hilti Flexible Firestop Sealant (CP 606) or equal.

6. Non curing, re-penetrable intumescent putty or foam materials for use with flexible cable or cable bundles, the following products are acceptable:

a. Hilti Firestop Putty Stick (CP 618) or equal.
b. Hilti Firestop Plug (CFS-PL) or equal.

7. Wall opening protective materials for use with U.L. listed metallic and specified nonmetallic outlet boxes, the following products are acceptable:

    a. Hilti Firestop Putty Pad (CP 617) or equal.
    b. Hilti Firestop Box Insert or equal.

C.

END OF SECTION 260500

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cables.
2. Connectors.
3. Solid terminations.
4. Separable insulated connectors.
5. Splice kits.
6. Medium-voltage tapes.
7. Arc-proofing materials.
8. Fault indicators.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, and other field conditions applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Material Certificates: For each type of cable and accessory.

C. Source quality-control reports.

D. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

C. Contractor shall store cable in a secure location both off site and on site. Storage shall ensure that cable is not exposed to the sun, water, or other weather elements for an extended period of time.

1.4 COORDINATION

A. The complete cable, raceway, and equipment system shall be entirely coordinated physically and electrically for proper fit and connection before submittal.

B. All physical sizes shall be confirmed so as not to exceed bend radius, proper working clearances, and permit field installation and removal through the openings and raceway provided.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. General Cable; Prysmian Group North America.
2. Kerite Power Cable; Marmon Holdings, Inc.; Berkshire Hathaway Inc.
3. Prysmian Power Cables
4. Okonite Company (The).
5. Southwire Company, LLC.
6. Superior Essex Inc.

B. Cable Type: Type MV 105.

C. Conductor Insulation: EPR - Ethylene-Propylene Rubber.

1. Voltage Rating: 5 and 15 kV.

2. Insulation Thickness: 133 percent insulation level.

D. Conductor: Copper.

E. Comply with UL 1072, AEIC CS8.

F. Conductor Stranding: Compact round, concentric lay, Class B conductor.

G. Strand Filling: Conductor interstices are filled with non carbon mineral compound.

H. Shielding: 5-mil Copper tape with 20% minimum overlap, helically applied over semiconducting insulation shield.

I. Three-Conductor “Triplexed” Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors.

1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

J. Cable Sheath: Interlocked galvanized steel or aluminum applied over cable per UL 1072 and UL 1569, CCW armor conductivity, meets the NEC article 250.

K. Cable Jacket: Sunlight-resistant PVC.

L. Tray Cable: Listed and labeled as suitable for installation in interior cable trays.

M. Cable shall be sealed against longitudinal water penetration at 5 psi water pressure per ICEA T-31-610.

N. 8KV non shielded MV-90 cable may be used for connection of Neutral Grounding Resistor at generator.

2.3 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Adalet (PLM) – Scott Fetzer Company.
3. ABB, Electrification Business (Elastimold).
4. Cooper Power Systems.
5. DSG-Canusa; Shawcor Ltd.
6. Eaton.
7. G&W Electric Company.
8. Richards Manufacturing.
9. TE Connectivity Ltd (Raychem).
10. Thomas & Betts Corporation.

B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

C. Copper-Conductor Connectors: Copper shear bolt connectors.

D. Live end seal kits: Medium voltage rated heat-shrinkable tube and a high dielectric strength, polymeric plug overlapping the conductor. IEEE 48.

E. Modular splicing systems with tightening by spanner wrench: Elastimold 600 Series with test point or equivalent

2.4 SOLID TERMINATIONS

A. See “2.3 A” above for Manufacturers list.Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Compound-filled, cast-metal-body, metal-clad cable terminator for metal-clad cable with external plastic jacket. Include Breakout-Boot, Re-jacketing Sleeve Assembly and termination material. Cold shrink Silicone Rubber three-conductor cable termination kit shall be compatible with the insulation type specified for the cable, suitable for both free-hanging or bracket-mount stand-off insulation type arrangements. The kit shall be 3M 7600-x-3G or approved equal.
2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors. Suitable for both free-hanging or bracket-mount stand-off insulation type arrangements. The kit shall be 3M 7600-x-3G or approved equal.

    a. “x” = “S” for skirted – Outdoor or Indoor Use.
    b. “x” = “T” for tubular – Indoor Use.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations:

    a. Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
    b. Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
    c. Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.

2. Class 2 Terminations, Indoor: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape; cold-shrink-rubber sleeve; or heat-shrink, plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200 A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

D. Dead-Break Cable Terminators: Elbow-type unit with 600 A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless steel mounting brackets, and attaching hardware.
   1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

B. See 2.3 “A” above for Manufacturers list.

C. Standard: Comply with IEEE 404.

D. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

   1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.

2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
3. Separable multiway splice system with all components for the required splice configuration.
4. Premolded, cold-shrink-rubber, in-line splicing kit.
5. Premolded, EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.7 MEDIUM-VOLTAGE TAPES

A. Description: Electrical grade, insulating tape rated for medium voltage application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. HellermannTyton.
3. Scapa Industrial; Scapa Group plc.

C. Silicone rubber-based, 12 mil self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inch wide.

D. Ethylene/propylene rubber-based, 30 mil splicing tape, rated for 130 deg C operation. Minimum 3/4 inch wide.

E. Insulating-putty, 125 mil elastic filler tape. Minimum 1-1/2 inch wide.

2.8 ARC-PROOFING MATERIALS

A. Description: Fire retardant, providing arc flash protection.

B. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. 3M.

C. Tape for First Course on Metal Objects: 10 mil thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

D. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, and compatible with cable jacket.

E. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch wide.

2.9 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576, NEC. ASTM and local codes and regulations.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inch on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation. Pulling-in compound of Plymouth/Bishop No.45, Minerallac H-2B as recommended by the cable manufacturer shall be used to ease pulling on all duct runs or conduits. Soap, oil or other active agents shall not be used.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.
5. Cable pulling tension shall be continuous throughout draw, without starts or stops, at 10 FPM average speed. It shall be the responsibility of the Contractor to obtain pulling tension recommendations and pulling tension formulas from cable manufacturer.
6. Wiring installations shall be made so that no undue stress is placed upon the insulation and coverings when they are drawn through the conduits, or otherwise handled. Ample slack wire shall be left at all terminal connections so that the stress is not placed on terminal studs and other connections.

7. Swivel shall be used at pulling cable connection. Waterproof pulling eye connected directly to conductor shall be the only pulling method allowed. Pulling eyes shall not be removed until ready for splicing or terminating cable.
8. Cable ends shall not be left overnight without proper seals. Contractor shall seal cable ends with Raychem ESC end caps.
9. After pulling, cables shall be supported at all times.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

G. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

H. Minimum bending radius per cable manufacturer data shall be rigidly adhered to at all times. Failure to follow this requirement shall be considered as sufficient evidence that cable has been irreparably damaged and must be replaced.

I. The minimum bending radius shall be 12 times the cable diameter or as specified by the manufacturer, whichever is smaller. This minimum bending radius shall not be exceeded during pulling-in operations, wiping, training and other cable moving operations.

J. The Contractor shall torque test conductor connections and terminations to manufacturer's recommended values.

K. The Contractor shall verify proper phasing connections.

L. Contractor shall take cable length readings when the cable is being spliced or terminated. These readings shall be provided to the Owner. Cable lengths must be recorded and included on the VLF test form before VLF testing can begin.

M. Contractor shall provide all additional materials required to properly pull, splice, and terminate 15 kV cables.

1. After making any cuts in cables, the Contractor shall furnish and promptly seal all exposed cable ends with Raychem seal kits to prevent contamination of the cable.
2. Splices in new medium voltage cable shall be made using splice kits. Splices shall be straight type.

N. Termination of Medium Voltage cable as follow:

1. Termination of medium voltage cables to Medium-Voltage Switchgear shall be made using stress cone termination kits and accessories.
2. Contractor shall provide all terminations (stress cone, deadbreak elbow, etc.) and splices.
3. Termination of medium voltage cables in AES service handoff manholes shall be made using modular separable deadbreak connectors. Coordinate with drawings. Coordinate with AES for service conductor size

O. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

P. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

Q. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.

R. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10 mil pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1 inch wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

S. Seal around cables passing through fire-rated elements according to Section 260500-3.2 "Firestopping."

T. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

U. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

B. Cable Testing and reporting:

1. Meggar test cable on reels at 5000VDC for one minute.
2. After the installation of new cable in conduit or ductbank, and prior to termination, cables shall again be meggar tested at 5000VDC for one minute.
3. Test the cable for insulation test by VLF-tan delta test after installation, splices, and termination have been made but before final connections to equipment and existing cable. Record time, voltage applied, loss angle (tan delta) and plot on graph paper.
4. Disconnect all surge arrestors and other shunt to ground devices prior to test. Reconnect after testing is complete.
    a. VLF-tan delta test.
    b. Leakage current test shall be by VLF-tan delta step voltage method.
    c. Prior to VLF-tan delta test, test the cable and shields for continuity, shorts, and grounds.
    d. VLF-tan delta test shall measure the leakage current from each conductor to the insulation shield.
5. Record and submit test results for approval prior to energization and shall include the following:
    a. Date.
    b. Project.
    c. Circuit identification.
    d. Cable manufacturer.
    e. Insulation rating.
    f. Conductor size.
    g. Temperature and humidity at time of test.
    h. Voltage increments.
    i. Stabilization time.
    j. VLF-tan delta test result.
    k. Test graphs. Plot results of voltage vs. loss angle (tan delta).
    l. Meggar ohm meter readings.
    m. Names and mode numbers of instruments used.
6. If any single cable fails testing, all three cables in raceway system shall be replaced and then retested per the above requirements.

C. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 260513

SECTION 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aluminum building wire
2. Copper building wire.
3. Metal-clad cable, Type MC.
4. Mineral-insulated cable, Type MI.
5. Tray cable, Type TC.
6. Fire-alarm wire and cable.
7. Connectors and splices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 601 to 35 000 V.
4. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

C. Wire and cable shall be color coded, with a separate color used for each phase and neutral used consistently through the system as specified in Identification section Green shall be used for all grounding conductors.

D. No material shall be used in the conductor system that cannot be identified under an approved material specification.

E. No material shall be installed that is corrosive, breeds or sustains mold growth, is moisture absorbing or whose properties exceed the following:

1. Flame spread 25 Max
2. Smoke developed 50 Max
3. Fuel contributed 50 Max

F. All wires and cables shall be delivered to the work site in complete coils with an approved tag containing manufacturer's name, wire size and type of insulation.

1.2 SUBMITTALS

A. Product Data:

1. Aluminum building wire
2. Copper building wire.
3. Mineral-insulated cable, Type MI.
4. Tray cable, Type TC.
5. Fire-alarm wire and cable.
6. Connectors and splices.

B. Product Schedule: Indicate type, use, location, and termination locations.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Alpha Wire; brand of Belden, Inc.
2. Belden Inc.
3. Cerro Wire LLC.
4. Encore Wire Corporation.
5. General Cable; Prysmian Group North America.
6. Okonite Company (The).
7. Service Wire Co.
8. Southwire Company, LLC.
9. WESCO.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 and TC-ER ASTM B496 for stranded conductors.

E. Conductor Insulation:

1. Type THHN and Type THWN-2. Comply with UL 83.
2. Type THW and Type THW-2. Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
3. Type XHHW-2. Comply with UL 44.
4. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
    a. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: See section 2.1, B for list.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

E. Conductor Insulation:

1. Type THHN and Type THWN-2. Comply with UL 83.
2. Type XHHW-2. Comply with UL 44.

2.3 MINERAL-INSULATED CABLE, TYPE MI

A. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. KME America, Inc.
2. PYROTENAX; brand of nVent Electrical plc.
3. Watlow Electric Manufacturing Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. UL 2196 for fire resistance.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper.

E. Insulation: Compressed magnesium oxide.

F. Sheath: Copper.

2.4 TRAY CABLE, TYPE TC

A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alpha Wire; brand of Belden, Inc.
2. Belden Inc.
3. Encore Wire Corporation.
4. General Cable; Prysmian Group North America.
5. Okonite Company (The).
6. Southwire Company, LLC.
7. WESCO.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1277.
3. RoHS compliant.
4. Comply with ICEA S-73-532/NEMA WC 57 for Type TC cables used for control, thermocouple extension, and instrumentation.
5. Comply with ICEA S-95-658/NEMA WC 70 for Type TC cables used for power distribution.
6. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors:

1. Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
2. Aluminum, complying with ASTM B800 and ASTM B801.

E. Ground Conductor: Insulated.

F. Conductor Insulation:
1) Type XHHW-2. Comply with UL 44.

2) Type THHN/THWN-2: Comply with UL 83.

2.5 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems; Atkore International.
2. Alpha Wire; brand of Belden, Inc.
3. Belden Inc.
4. Encore Wire Corporation.
5. General Cable; Prysmian Group North America.
6. Okonite Company (The).
7. Southwire Company, LLC.
8. WESCO.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:

1. Single circuit.

E. Conductors:

1. Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
2. Aluminum, complying with ASTM B800 and ASTM B801.

F. Ground Conductor: Insulated.

G. Conductor Insulation:

1. Type THHN/THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

H. Armor: Steel or Aluminum, interlocked.

I. Jacket: PVC applied over armor.

2.6 MINIMUM CONDUCTOR SIZE

A. Branch Circuits: No. 12 AWG, up size the conductor for following:

1. 20A, 120V circuits longer than 75 feet: No. 10 AWG.
2. 20A, 120V circuits longer than 150 feet: No. 8 AWG.
3. 20A, 277V circuits longer than 150 feet: No. 10 AWG.

B. Motor Control Circuits: No. 14 AWG.

C. Flexible connections and pendants for lighting fixtures: No. 14 AWG stranded.

D. Annunciator Wiring: No. 16 AWG TFF, TFFN, THHN, stranded.

2.7 FIRE-ALARM WIRE AND CABLE

A. See Section 280513 for requirements.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG, size as recommended by system manufacturer. See Section 280513 for requirements.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.8 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. 3M Electrical Products.
2. ABB, Electrification Business.
3. Hubbell Utility Solutions; Hubbell Incorporated.
4. ILSCO.
5. Ideal Industries, Inc.
6. NSi Industries LLC.
7. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
8. TE Connectivity Ltd.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast compression or set screw type with grounding / sealing ring where noted , designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper or Aluminum – (Based on conductor material).
2. Type: Two hole with standard or long barrels.
3. Termination: Crimp or Compression – (Based on Manufacturer).

E. Wiring connectors for Splices and Taps:

1. Copper Conductors No. 10 AWG and Smaller: Use insulated vinyl covered spring devices (“Scotch lock”, “Wire nut”, or equal). Copper sleeves are not acceptable wiring connections.
   a. Motors (480V or less): For No. 10 AWG and smaller conductors – Provide taped connector eye lug of motor lead to looped input conducts, using machine bolt/nut arrangement to facilitate rapid disconnecting.
   b. Connections under screw head terminals: Solid conductors shall have formed eyes; stranded conductors shall have an approved nylon compression terminals as T&B “Sta-Kon” or approved equal.
   c. Connection on receptacles can be back wired if receptacle is provided with a screw and clamp feature.
2. Copper Conductors No. 8 AWG and Larger: Use mechanical connectors or compression connectors.

F. Wiring Connectors for Terminations:

1. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
2. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
3. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.

4. Provide motor pigtail connectors for connecting motor leads to facilitate disconnection.
5. Conductors No. 8 AWG and Larger: Use mechanical connectors or compression connectors where connectors are required.
6. Conductors No. 10 AWG and Smaller: Use crimped terminals for connections to terminal screws.
7. Conductors for Control Circuits: Use crimped terminals for all connections.

G. Mechanical Connectors:

1. High strength, high copper allows split-bolt connectors (Burndy “Servit” or approved equivalent) shall be utilized for joining No. 8 AWG and larger conductors to No. 10 AWG and smaller conductors. The split-bolt connectors shall be heavily insulated with tape.

H. Compression Connectors:

1. High strength, high copper alloy with heavy reinforcing ribs for joining No. 8 AWG and larger conductors. Compression splice shall be heavily insulated with heat/cold shrink or tape.

I. Crimped Terminals: Nylon-insulation grip and terminal configuration suitable for connection to be made.

2.9 ELECTRICAL TAPE

A. Normal temperature installations use electrical tape (Scotch #33, 88).

B. For wet locations use self-vulcanizing rubber insulating tape equal to electrical tape (Scotch #2210) with vinyl tape outer coat.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders and Branch Circuits:
1. Copper for all sizes.
2. Aluminum for circuits over 150 amps.
3. Copper. Solid or stranded for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

B. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders above ground: Type THHN/THWN-2, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

D. **Feeders in Cable Tray: Type THHN/THWN-2, single conductors, Type XHHW-2, single conductors larger than No. 1/0 AWG, Tray Cable, with metal-sheathed, type MC or nonmetallic-sheathed cable, Type TC.**

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. VFC Output Circuits: Type XHHW-2 in metal conduit or Type TC-ER cable with braided shield.

3.3 INSTALLATION, GENERAL

A. Complete raceway installation between conductor and cable termination points in accordance with Section 260533 - Raceways and Boxes for Electrical Systems prior to pulling conductors and cables.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

F. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

G. Each single-phase branch circuit shall be provided with its own 100% (same size as phase conductor) dedicated neutral conductor. Sharing of the neutral conductor between multiple circuits shall not be allowed.

1. When more than one neutral is in a common raceway, junction box, etc. each neutral shall be clearly identified with its associated phase conductor.
2. Each branch circuit conduit shall contain a separate green equipment grounding conductor.

H. Conductors shall be continuous from outlet to outlet.

I. Neatly train and lace wiring inside boxes, equipment, panelboards, etc.

J. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.

K. Maintain separation of wiring for emergency systems in accordance with NFPA 70.

L. Circuit Adjustments: Unless otherwise indicated, combining branch circuits together in a single raceway is permitted, under the following conditions:

1. Provide no more than six current-carrying conductors in a single raceway. Dedicated neutral conductors are considered current-carrying conductors. Or as noted on drawings.
    a. E.C. may modify circuits identified as combined in raceway on drawings.
        1) Submit to Engineer all wiring and raceway changes for approval.
2. Increase size of conductors as required to account for ampacity derating.
3. Up size raceway, boxes, etc. to accommodate conductors.
4. Branch circuits originate from the same panel or switchboard.

M. Parallel Conductors: Install conductors of the same length and terminate in the same manner.

N. Protect exposed cable from damage.

O. Installation in Raceway:
1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
2. Do not damage conductors and cables or exceed manufacturer’s recommended maximum pulling tension and sidewall pressure.

P. Where required by enclosure size, temperature space, etc., provide stranded wiring for temperature control wiring, interlocks, etc.

3.4 INSTALLATION OF FIRE-ALARM WIRING

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal pathway according to Section 270528.29 "Hangers and Supports for Communications Systems."

1. Fire-alarm circuits and equipment control wiring associated with fire-alarm system shall be installed in a dedicated pathway system. This system shall not be used for any other wire or cable.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.

E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

F. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.

G. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.

D. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor.

E. Wiring connections using specified wiring connectors:

1. Make splices and taps only in accessible boxes. Do not pull splices into conduit or make splices in conduit bodies or wiring gutters.
2. Do not remove conductor strands to facilitate insertion into connector. Provide pig tail connection.
3. Clean contact surfaces on conductors and connectors to suitably remove corrosion, oxides, and other contaminants. Do not use wire brush on plated connector surfaces.
4. Splices are not acceptable in home runs.

F. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.

G. Insulate ends of spare conductors using insulated vinyl covered spring devices (“Scotch lock”, “Wire nut”, or equal) and vinyl insulating electrical tape.

H. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

I. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

J. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

3.6 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 260500-3.2 "Firestopping."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each of the following visual and electrical tests:

   a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
   b. Test bolted connections for high resistance using one of the following:

      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
      3) Thermographic survey.

   c. Inspect compression-applied connectors for correct cable match and indentation.
   d. Inspect for correct identification.
   e. Inspect cable jacket and condition.
   f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
   g. Continuity test on each conductor and cable.
   h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

   a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Twin-axial data highway cable.
2. RS-232 cable.
3. RS-485 cable.
4. Control cable.
5. Control-circuit conductors.
6. Fire-alarm wire and cable.

1.2 SUBMITTALS

A. Product Data:
1. RS-232 cable.
2. RS-485 cable.
3. Control cable.
4. Control-circuit conductors.
5. Fire-alarm wire and cable.

B. Sustainable Design Submittals:

1. Product Data: For each conductor and cable indicating lead content.
2. Environmental Product Declaration: For each product.
3. Health Product Declaration: For each product.
4. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inch or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.2 RS-232 CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Wire & Cable Inc.
2. Belden Inc.
3. General Cable; Prysmian Group North America.
4. Genesis Cable Products; Honeywell International, Inc.
5. Southwire Company, LLC.

B. PVC-Jacketed, TIA 232-F:

1. Three, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Lead Content: Less than 300 parts per million.
3. Polypropylene insulation.
4. Aluminum foil-polyester tape shield with 100 percent shield coverage.
5. PVC jacket.
6. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
7. NFPA 70 Type: Type CM.
8. Flame Resistance: Comply with UL 1581.

C. Plenum-Type, TIA 232-F:

1. Three, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Lead Content: Less than 300 parts per million.
3. PE insulation.
4. Aluminum foil-polyester tape shield with 100 percent shield coverage.
5. Fluorinated ethylene propylene jacket.
6. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
7. Flame Resistance: Comply with NFPA 262.

2.3 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CMG.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.
6. Lead Content: Less than 300 parts per million.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262.
6. Lead Content: Less than 300 parts per million.

2.4 CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.
6. Lead Content: Less than 300 parts per million.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.
6. Lead Content: Less than 300 parts per million.

2.5 CONTROL-CIRCUIT CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Encore Wire Corporation.
2. General Cable; Prysmian Group North America.

3. Service Wire Co.
4. Southwire Company, LLC.

B. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

C. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1. Smoke control signaling and control circuits.

2.6 FIRE-ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Wire & Cable Inc.
2. CommScope, Inc.
3. Comtran Corporation.
4. Genesis Cable Products; Honeywell International, Inc.
5. Prysmian Cables and Systems; Prysmian Group North America.
6. Radix Wire.
7. Rockbestos-Suprenant Cable Corp.
8. Superior Essex Inc.; subsidiary of LS Corp.
9. West Penn Wire; brand of Belden, Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

1. Lead Content: Less than 300 parts per million.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 16 AWG or as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Control-Voltage Circuits: No. 16 AWG, minimum, in pathway.

2. Low-Voltage Circuits: No. 12 AWG, minimum, in pathway.

2.7 SOURCE QUALITY CONTROL

A. Factory test twisted pair cables according to TIA-568-C.2.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 – “Raceways and Boxes for Electrical Systems” for raceway selection and installation requirements for conduits as supplemented or modified in this Section.

B. Comply with requirements in Section 260533 – “Raceways and Boxes for Electrical Systems” for raceway selection and installation requirements for boxes as supplemented or modified in this Section.

1. Outlet boxes must be no smaller than 2 inch wide, 3 inch high, and 2-1/2 inch deep.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Terminate all conductors; cable must not contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
3. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.

4. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
5. Secure and support cables at intervals not exceeding 30 inch and not more than 6 inch from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Support: Do not allow cables to lie on removable ceiling tiles.
10. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
11. Provide strain relief.
12. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
13. Ground wire must be copper, and grounding methods must comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Install termination hardware as specified in Section 271513 "Communications Copper Horizontal Cabling" unless otherwise indicated.
3. Do not untwist balanced twisted pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.
2. Use insulated spade lugs for wire and cable connection to screw terminals.

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.

2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.6 FIRESTOPPING

A. Comply with requirements in Section 260500-3.2 "Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 GROUNDING

A. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers must use label stocks, laminating adhesives, and inks complying with UL 969.

C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

B. End-to-end cabling will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Test wells.
2. Ground rods.
3. Ground Conductors.
4. Grounding Connectors.
5. Exothermic Welds.

B. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. Include the following:

a. Plans showing as-built, dimensioned locations of grounding system, including the following:

1) Test wells.
2) Ground rods.
3) Ground rings.
4) Grounding arrangements and connections for separately derived systems.
5) Connection to Lightning Protection System.

b. Include approved shop drawing.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. ERICO; brand of nVent Electrical plc.
3. ILSCO.
4. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
5. Thomas & Betts Corporation: A member of ABB Group.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B3
2. Stranded Conductors: ASTM B8
3. Tinned Conductors: ASTM B33.
4. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.
5. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
6. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Mechanical-Type Bus-Bar Connectors: Cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Compression-Type Bus-Bar Connectors: Copper or copper alloy, with two wire terminals.

E. Compression Connection: Brundy Hyground System

F. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

G. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

H. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

I. Conduit Hubs: Mechanical type, terminal with threaded hub.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

L. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

M. Straps: Solid copper, cast-bronze clamp or copper lugs. Rated for 600 A.

N. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal [**one**] [**two**]-piece clamp.

O. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

P. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless steel bolts.

    a. Material: Die-cast zinc alloy.
    b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING AND BONDING BUSHINGS

A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between

bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Bonding Bushing:
1. General Characteristics: Threaded bushing with insulated throat.

D. UL KDER - Grounding Bushing:

1. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.6 GROUNDING AND BONDING HUBS

A. Description: Hubs with certified grounding or bonding locknut.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Grounding and Bonding Hub:

1. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.7 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding device that serves as common connection for multiple grounding and bonding conductors.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Equipment Room Grounding and Bonding Busbar:

1. General Characteristics:

a. Bus: Rectangular bar of annealed copper.
b. Mounting Stand-Off Insulators: Lexan or PVC.

1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.

2. Dimensions: 1/2 by 4 inch in cross section; length as indicated on Drawings.

3. Predrilled Hole Pattern: multiple holes spaced apart. Suitable for installing specified grounding and bonding connectors.

4. Mounting Hardware: Stand-off brackets that provide 2 inch minimum dimension clearance to access rear of bus. Brackets and bolts must be stainless steel.

2.8 GROUNDING ELECTRODES

A. Description: Grounding electrodes include rod electrodes, ring electrodes, metal underground water pipes, metal building frames, concrete-encased electrodes, and pipe and plate electrodes.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. Rod Electrode: Copper-clad steel, sectional type; 3/4 inch by 10 ft.

D. Plate Electrode: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum unless specified otherwise.

1. Bury at least 30 inch below grade.
2. Duct-Bank Grounding Conductor: Encased with duct bank when indicated as part of duct-bank installation.

B. Grounding Conductors: Green-colored insulation with continuous.

C. Isolated Grounding Conductors: Green-colored insulation with more than one continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inch minimum from wall, 18 inch above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors or Brundy Hyground System and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors must be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses where applicable.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: The grounding electrode must be connected to the equipment grounding conductor and to the frame of the generator. Install a main bonding jumper between the neutral and ground bus.

B. Substation: The grounding electrode must be connected to the equipment grounding conductor and to the frame of the substation. At transformer secondary install a main bonding jumper between the neutral and ground bus.

C. Unit Transformer: The grounding electrode must be connected to the equipment grounding conductor and to the frame of the unit transformer. At transformer secondary install a main bonding jumper between the neutral and ground bus.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. See Section 260543 “Underground Ducts and Raceways for Electrical Systems.”

C. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch above to 6 inch below concrete. Seal floor opening with waterproof, nonshrink grout.

D. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

3.6 FENCE GROUNDING

A. Fence Grounding: Install at maximum intervals of 1500 ft. except as follows:

1. Fences within 100 ft. of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 ft..

a. Gates and Other Fence Openings: Ground fence on each side of opening.

1) Bond metal gates to gate posts.

B. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inch below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

C. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

D. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.7 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inch below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. Use exothermic welds or Brundy Hyground System for all below-grade connections.
3. Use ground rod extensions up to 20 feet (6 meters) maximum when needed to reach suitable soil.

D. Test Well: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least 12 inch (300 mm) deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors or Brundy hyground System for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft. apart.

H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of area or item indicated.

1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel unless specified otherwise.
2. Bury ground ring not less than 36 inch from building's foundation.

I. Concrete-Encased Grounding Electrode (Ufer Ground)

1. Fabricate in accordance with NFPA 70; use minimum of 20 ft (6 m) of bare copper conductor not smaller than 4 AWG.

    a. If concrete foundation is less than 20 ft (6 m) long, coil excess conductor within base of foundation.
    b. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

2. Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft (6.0 m) long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.

J. All panelboards and switchboards shall contain a grounding bus.

K. Separately derived systems:

1. System shall be grounded per NEC.
2. Where a neutral is derived, a grounding electrode conductor shall be run to one of the following:

    a. The building grounding electrode system bus bar.
    b. A common electrode grounding conductor designed as described in NEC for such applications.
    c. The nearest available effectively grounded structural member.
    d. Metal water pipe grounding electrode as specified in NEC.

3. The grounding electrode conductor shall be routed from the Xo of the transformer in the derived system.

L. Grounding electrode system:

1. Within the building main electrical room, install a copper bus bar, to act as the grounding electrode system termination point for all grounding electrodes as described in NEC. This shall be called the building grounding electrode system bus bar.

M. Equipment Grounding:

1. All new equipment shall be equipped with grounding provisions per current NEC requirements.

N. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.8 LABELING

A. Comply with requirements in Division 26 "Identification for Electrical Systems" for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system, measure ground resistance at reference ground bus in electrical room. Ground resistance shall not exceed 5 ohms.

    a. Perform tests by fall-of-potential method according to IEEE 81.

B. Grounding system will be considered defective if it does not pass tests and inspections.

1. Remove and replace defective components and retest.

C. Prepare test and inspection reports.

D. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to record of tests and observations. Include number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Support, anchorage, and attachment components.
2. Fabricated metal equipment support assemblies.

1.2 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Fasteners.
e. Anchors.
f. Saddles.
g. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

D. Welding certificates.

1.3 COORDINATION

A. Coordinate size and location of concrete bases with equipment shop drawing. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 "Roof Accessories."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

D. Comply with NECA 1 and NFPA 70; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

E. Products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.
   1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   2. Material for Channel, Fittings, and Accessories: Galvanized steel.
   3. Channel Width: Selected for applicable load criteria minimum 1-5/8 inch.
   4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   5. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical

conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
5. Toggle Bolts: Stainless steel springhead type.
6. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA NEIS 101
2. NECA NEIS 105.

B. Comply with requirements in Section 260500-3.2 "Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."

D. Provide vibration and seismic controls with hangers and supports in accordance with requirements specified in "Section 260548.16 "Seismic Controls for Electrical Systems."

E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as NFPA 70. Minimum rod size must be 1/4 inch in diameter.

F. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA NEIS 1, raceway may be supported by openings through structure members, in accordance with NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts and/or Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inch larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use minimum 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete" or detail on drawing.

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

D. Interior pads shall be Class II cement, shall have 3/4” chamfered edges. Pads shall be doweled to the floor in at least four places (each conduit penetration may be counted for one dowel). Pads shall have heavy mesh reinforcing and have any existing floor coating re-extended to the lower edge of the chamfer.

3.5 PAINTING

A. Touchup:

1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

    a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 260529

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Boxes, enclosures, and cabinets.
6. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 260500-3.2 "Firestopping" for firestopping at conduit and box entrances.
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.
3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.2 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. EMT: Electrical Metallic Tubing.

C. GRC: Galvanized rigid steel conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight Flexible Metal Conduit.

F. RNC: Rigid Nonmetallic Conduit (Rigid Polyvinyl Chloride Conduit: Type PVC).

1.3 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Sustainable Design Submittals:

1. Product Data: For solvents and adhesives, indicating VOC content.

2. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Calconduit; Atkore International.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Patriot Aluminum Products, LLC.
f. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
g. Topaz Lighting & Electric.
h. Western Tube; Zekelman Industries.
i. Wheatland Tube; Zekelman Industries.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. EMT: Comply with ANSI C80.3 and UL 797.
5. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
5. Fittings for EMT:

    a. Material: Steel.
    b. Comply with NEMA FB 2.10, Type: Steel compression for 2" or smaller and steel setscrew for larger than 2", insulated throat, concrete tight type couplings and connectors similar to Appleton #TWXX-SI Series, OZ/Gedney #4000-ST/5000-ST Series, and meeting Federal Spec #WF408F. Other fittings shall not be acceptable.

6. Fitting for GRC: Comply with NEMA FB 2.10, all threaded fittings (use of set screw or compression type not acceptable).
7. Liquid tight fittings: Comply with NEMA FB 2.20, shall be UL listed for grounding, ferrule and sleeve type with insulated throat as O-Z Gedney "4Q" series, Appleton 'ST" Carlon "Carflex" or approved equal.
8. Conduit Hubs shall have insulated throat and recessed O-Ring seal.
9. Conduit Bodies:

    a. "LB" and Mogul size for 1" and larger conduits.
    b. Cast ferrous material for exterior, watertight, and vapor tight locations with gaskets at covers.

10. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

C. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

D. GRC for underground or pour in concrete walls shall be conductive, waterproof joint compound equal to T&B "KOPR-SHIELD" or Sherwin Williams 'ZINC-CLAD".

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
3. LFNC: Comply with UL 1660.
4. Continuous HDPE: Comply with UL 651A.

5. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

B. Nonmetallic Fittings:
1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

a. Fittings for LFNC: Comply with UL 514B.

3. Solvents and Adhesives: As recommended by conduit manufacturer.
4. Verify adhesive complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
2. Appleton; Emerson Electric Co., Automation Solutions.
3. Arlington Industries, Inc.

4. Crouse-Hinds; brand of Eaton, Electrical Sector.
5. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
6. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
7. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
8. MonoSystems, Inc.
9. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
10. Pass & Seymour; Legrand North America, LLC.
11. Patriot Aluminum Products, LLC.
12. Plasti-Bond; Robroy Industries.
13. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
14. Spring City Electrical Manufacturing Company.
15. Topaz Lighting & Electric.
16. Wiremold; Legrand North America, LLC.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A; galvanized steel.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover and threaded hubs.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

1. Through wall and Handy boxes are not permitted.
2. Four inch octagon or square boxes for fixture outlets.

J. Gangable boxes are not allowed.

K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 4, and Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel. Type 4 shall be stainless steel.

2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

L. Cabinets:

1. NEMA 250, Type 1, Type 3R, and Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. NEMA 250 Type 4 stainless steel box with removable interior panel and removable front, finished inside with manufacturer's standard enamel.
3. Hinged door in front cover with flush latch and concealed hinge.
4. Key latch to match panelboards.
5. Metal barriers to separate wiring of different systems and voltage.
6. Accessory feet where required for freestanding equipment.
7. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
8. Backboard: Provide 3/4" thick plywood backboard for mounting terminal blocks and other electronics.

M. Terminal Blocks

1. Terminal Blocks: NEMA ICS 4.
2. Power Terminals: Unit construction type with closed back and tubular pressure screw connector, rated 600 volts minimum.
3. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 300 volts minimum.
4. Provide ground bus terminal block with each connector bonded to enclosure or cabinet.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit (general purpose): GRC.
2. Exposed Conduit (Exposed to cooling tower water): ARC.
3. Concealed Conduit, Aboveground: GRC.
4. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
5. All explosion proof work (rigid only): GRC.
6. "Vaportight" and "watertight" work: GRC.
7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
8. Boxes and Enclosures, Aboveground: NEMA 250, Type 4X.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.

2. Exposed, Subject to Physical Damage or located less than +10'-0" above finished floor: GRC.
3. Concrete slabs and all poured walls (1-inch minimum concrete cover): GRC
4. Below bottom of lowest slab in granular fill: GRC
5. Concealed feeder conduit in Ceilings and Interior Walls and Partitions: EMT.
6. Concealed Branch Circuit in Ceilings and Interior Walls and Partitions: EMT.
7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC. Six feet maximum length unless otherwise noted.
8. Damp or Wet Locations: GRC or LFMC per application.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4X stainless steel where exposed to cooling tower water or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

1. See communications specifications for telecom raceway sizes.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use setscrew fitting for larger than 2" C and compression fitting for 2" and smaller conduit, steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with LFMC conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Separate raceway systems shall be provided for:

1. Each lighting system.
2. Convenience outlets.
3. Each power system.

4. Each special or different system as further specified whether it is battery lighting, high or low voltage or any nature, such as telephone, fire alarm, emergency system, sound, control systems, Building Automation Control Systems, etc.
5. Except by special permission, separate conduits are required for each feeder, each equipment branch circuit, and for all special systems.

D. Common conduits will be acceptable for:

1. Branch circuits originating from the same panel for lighting and outlets.
2. Motor branch circuits, or for a motor circuit and its associated control wiring.
3. Power or lighting and lighting control wiring can be in the same conduit provided the insulation on the control wiring is greater than the highest voltage in the raceway.

E. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

F. Do not fasten conduits onto the bottom side of a metal deck roof.

G. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

H. Complete raceway installation before starting conductor installation.

I. Arrange stub-ups so curved portions of bends are not visible above finished slab.

J. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

K. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

L. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines. Conduits located in mechanical and electrical spaces may be exposed.

M. Install conduit parallel and perpendicular to walls and building lines. Conduit under slab may be routed from point-to-point.

N. Arrange raceway to maintain headroom and present neat appearance. Install 1” or less below deck to avoid future conflicts when ceilings are installed or when additional work is added.

O. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.

P. Do not attach conduit to ceiling support wires.

Q. Install underground conduit within the building perimeter a minimum of 6 inches below the drainage fill under the concrete slab.

R. Install all branch circuit conduits within the building perimeter above the finished floor line except when serving floor boxes, outlets in partial height walls, or exterior connections where shown or unless otherwise noted on contract documents. Floor boxes, partial height walls, or exterior connections shall be served from the floor below.

S. Provide insulated throat metal grounding bushings with lay-in type lug for all feeder conduits.

T. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one shot bender to fabricate bends in metal conduit larger than 2 inch size.

U. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

V. Use suitable caps to protect installed conduit against entrance of dirt and moisture.

W. Route conduit through same roof openings as piping and ductwork wherever possible. Where separate roofing penetration is required, coordinate location and installation method with roofing installation.

1. One conduit per sleeve.
2. Minimum height of sleeve not less than 8-inches above roof membrane.
3. Provide rain shield on conduit overlapping sleeve a minimum of 2-inches.
4. Secure rain shield to conduit with stainless steel pressure clamps.
5. Provide flashing as required.

X. Support conduit within 12 inches of enclosures to which attached.

Y. Raceway embedded in slab and under floor slab are not permitted unless otherwise indicated on the contract documents.

Z. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

AA. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

BB. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

CC. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

DD. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

EE. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. De-burr cut ends.

FF. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

GG. GRC conduit installation as follow:

1. Coupled with Erickson Couplings in lieu of running threads.
2. Installed with joints sealed with conductive, waterproof conduit joint compound (where underground or in concrete), equal to T & B "KOPR-SHIELD" or Sherwin Williams "ZINC-CLAD".
3. Installed in accordance with Underwriters Laboratories Standard UL6 for Rigid.
4. Where GRC enters a box or other fitting through a knockout, an approved double locknut and bushing shall be provided. Not applicable for threaded hubs.
5. Used for sleeves except where sheet metal is approved elsewhere.
6. Installed with all threaded fittings (the use of set screw or compression type not acceptable).
7. Where exiting or entering a concrete slab, extend Rigid at least 36" before adapting to EMT.
8. In unfinished areas, conduit runs exposed below 10’-0” shall be GRC. Above 10’-0” and not subject to physical damage, such as by crane or hoist, GRC may transition to EMT
9. Where Rigid enters a junction box or any enclosure within 60" of exiting or entering a concrete slab, the Rigid shall be continuous into the enclosure.
10. Conduit hubs shall be installed for all GRC terminations to sheet metal type enclosures and for installations requiring a watertight or dust tight seal.

HH. Rigid Non-Metallic Conduit (PVC):

1. Underground site lighting branch circuits only, no concrete encasement is required. Other types of installations may require concrete encasement as indicated on the drawings, other sections of these specifications, and as directed by the Owner or NEC.
2. Entire installation shall be watertight.
3. Where exiting or entering a concrete slab, PVC shall be adapted to Rigid at least 12-inches prior to exiting or entering the slab.
4. Covered PVC shall be used for Engine-Generator Control and Power Wiring.

II. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

JJ. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

KK. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

LL. Expansion-Joint Fittings:

1. Install in each run of aboveground GRC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

MM. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

NN. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

1. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
2. Align wall mounted outlet boxes for switches, thermostats, and similar devices.

OO. Install boxes in locations as shown on the drawings, as required for splices, taps, wire pulling, equipment connections, and as required by NFPA 70.

1. Electrical boxes shown on drawings are approximate locations unless otherwise indicated. Adjust box locations up to 10 feet if required to accommodate intended purpose.
2. Locate boxes to allow luminaries positioned as shown on reflected ceiling plan.
3. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel; provide a minimum 6” separation. Provide a minimum 24” separation in acoustic rated walls.
4. Coordinate installation of outlet boxes for equipment connected under Section “Wiring Devices”.

PP. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

QQ. Locate boxes so that cover or plate will not span different building finishes.

RR. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose. Secure flush mounting box to interior wall partition studs. Accurately position to allow for surface finish thickness.

1. Use stamped steel bridges to fasten flush mounting outlet box between studs.
2. Adjust flush installed outlets to make front flush with finished wall material.

SS. Install boxes, enclosures, and cabinets plumb. Anchor securely to structural supports.

TT. Orient boxes vertically to accommodate wiring devices unless otherwise noted.

UU. Use flush mounting outlet box in finished areas.

VV. Use surface mounted boxes in unfinished.

WW. Install knockout closures in unused box openings.

XX. Install pull boxes and junction boxes above accessible ceiling and in unfinished areas only.

YY. Use cast outlet boxes in exterior locations exposed to weather and wet locations.

ZZ. Large Pull Boxes: Use hinged enclosure in interior dry locations, surface-mounted cast metal box in wet locations.

AAA. Clean interior of boxes and remove dust, debris and other material prior to wire or device installation. Clean exposed surfaces and restore finish. Touch up damage.

BBB. Contractor shall maintain J-Box accessibility. When an outlet, junction box, or pull box becomes inaccessible for any reason (i.e. new lab benches or cabinets) the outlet, junction box, or pull box shall be relocated and all associated conduit and wiring modified and re-routed as required maintaining accessibility.

CCC. Route conduit away from any equipment requiring maintenance access, minimum 24-inches clearance.

DDD. Comply with requirements in Division 26 "Identification for Electrical Systems" for raceway and Boxes identifications.

EEE. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits and /or ceiling support wire.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 260500-3.2 "Firestopping."

1. Firestop cables in conduit penetrating rated wall/floor within the building.

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260533.11 – ELECTRICAL HEAT TRACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes heat tracing for piping with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

B. Field quality-control reports.

1.5 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace electric heating cable and system devices that fails in materials or workmanship within warranty period.

1. Warranty Period: two years from date of substantial completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. nVent (Raychem).
2. Thermon Americas Inc.

B. Comply with IEEE 515.1.

C. Heating Element: Pair of parallel No. 16 AWG, nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

D. Electrical Insulating Jacket: Flame-retardant polyolefin.

E. Cable Cover: Tinned-copper braid and polyolefin outer jacket with ultraviolet inhibitor.

F. Maximum Operating Temperature (Power On): 150 deg F.

G. Maximum Exposure Temperature (Power Off): 185 deg F.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Capacities and Characteristics:

1. Maximum Heat Output: Use standard heating cable sizes, based on application – 3 W/ft, 5 W/ft, 10 W/ft, 15 W/ft, or 20 W/ft.
2. Electrical Characteristics for Single-Circuit Connection:

a. Volts: 120 or 208
b. Phase: 1
c. Full-Load Amperes: 20A or Maximum 30 Amps

2.2 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Sections 230553 and 260553 "Identification" for Heat Tracing of piping and Equipment.

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. See Heat Trace Schedule on sheet EP608.

B. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.

C. Install electric heating cables after piping has been tested and before insulation is installed.

D. Install electric heating cables according to IEEE 515.1.

E. Install insulation over piping with electric cables according to Section 230719 "Piping Insulation."

F. Install warning tape on piping insulation where piping is equipped with electric heating cables.

G. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed heating cables, including non-heating leads, from damage during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION 260533.11

SECTION 260536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ladder cable tray.
2. Cable tray accessories.
3. Warning signs.

B. Related Requirements:
1. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories serving communications systems.
2. Division 260500-3.2 ‘Firestopping”.
3. Division 26 "Grounding and Bonding for Electrical Systems".
4. Division 26 "Hangers and Supports for Electrical Systems".

1.2 SUBMITTALS

A. Product Data: For each type of product.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

a. Vertical and horizontal offsets and transitions.
b. Clearances for access above and to sides of cable trays.
c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Delegated Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer who is licensed in the state where Project is located and who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

D. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design cable tray supports and seismic bracing.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAY

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAY

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB, Electrification Business.
2. Chalfant Manufacturing Company.
3. Cooper B-line; brand of Eaton, Electrical Sector.
4. Cope; Atkore International.

5. MP Husky USA Cable Tray & Cable Bus.
6. MonoSystems, Inc.
7. Niedax Inc.

B. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: 24 inch unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 6 inch, unless otherwise indicated on Drawings.
4. Rung Spacing: 9 inch on center.
5. Radius-Fitting Rung Spacing: 9 inch at center of tray's width.
6. Minimum Cable-Bearing Surface for Rungs: 7/8 inch width with radius edges.
7. No portion of the rungs must protrude below the bottom plane of side rails.
8. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200 lb. concentrated load, when tested according to NEMA VE 1.
9. Fitting Minimum Radius: 24 inch, unless otherwise indicated on Drawings.
10. Class Designation: Comply with NEMA VE 1, [**Class 5AA**] [**Class 5A**] [**Class 8AA**] [**Class 8A**] [**Class 10AA**] [**Class 10A**] [**Class 12AA**] [**Class 12A**] [**Class 20AA**] [**Class 20A**].
11. Splicing Assemblies: Bolted type using serrated flange locknuts.
12. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.
13. Covers: Solid with 2-in-3 pitch type made of same materials and with same finishes as cable tray.

C. Materials and Finishes:

1. Steel:

   a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33.
   b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
   c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
   d. Finish:

      1) Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2, with galvanized, ASTM B633 hardware.

2. Aluminum:

   a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
   b. Hardware: Chromium-zinc-plated steel, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594.

c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

2.4 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.5 WARNING SIGNS

A. Lettering: 1-1/2 inch high, black letters on yellow background, with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Comply with Section 260553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 INSTALLATION OF CABLE TRAY

A. Install cable tray and support systems according to NEMA VE 2.

B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square-neck carriage bolts and locknuts.

F. Fasten cable tray supports to building structure and install seismic restraints.

G. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." Comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."

H. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support assembly to prevent twisting from eccentric loading.

K. Do not install more than one cable tray splice between supports.

L. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

M. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps according to applicable standard.

N. Make changes in direction and elevation using manufacturer's recommended fittings.

O. Make cable tray connections using manufacturer's recommended fittings.

P. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 260500-3.2 "Firestopping."

Q. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

R. Install cable trays with enough workspace to permit access for installing cables.

S. Install barriers to separate cables of different systems, such as power, communications, and data processing, or of different insulation levels, such as 600, 5,000, and 15,000 V.

T. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Cable trays with electrical power conductors must be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors must be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72 inch intervals. The grounding conductor must be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 INSTALLATION OF CABLES

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inch.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure must be no more than 72 inch.

E. Tie mineral-insulated cables down every 36 inch where required to provide a two-hour fire rating and every 72 inch elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.

2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and must remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 260536

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Polymer concrete handholes and boxes with polymer concrete cover.
6. Precast manholes.

1.3 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

D. GRC: Galvanized rigid (steel) conduit.

E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including spacers and miscellaneous components.
2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include underground-line warning tape.
5. Include warning planks.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including locations and duct sizes.
c. Include reinforcement details.
d. Include frame and cover design and manhole chimneys.
e. Include ladder details.
f. Include grounding details.
g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

C. Sustainable Design Submittals:

1. Product Data: For adhesives and sealants, indicating VOC content.
2. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.

D. Product Certificates: For concrete and steel used in precast concrete manholes, as required by ASTM C 858.

E. Source quality-control reports.

F. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Ground Water: Assume ground-water level is 12 feet below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. CANTEX INC.
4. Carlon; a brand of Thomas & Betts Corporation
5. Crown Line Plastics.
6. Electri-Flex Company.
7. Endot Industries Inc.
8. IPEX USA LLC.
9. Manhattan/CDT.
10. National Pipe & Plastics.
11. Opti-Com Manufacturing Network, Inc (OMNI).

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

1. VOC Content: 510 g/L or less for PVC conduit and fittings.

2.3 FLEXIBLE NONMETALLIC DUCTS

A. HDPE Duct: Type EPEC-40 HDPE, complying with NEMA TC 7 and UL 651A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Blue Diamond Industries, LLC.
    b. JM Eagle.
    c. Petroflex North America.
    d. Prysmian Cables and Systems; Prysmian Group North America.
    e. Southwire Company, LLC.

2. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.4 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; a part of Atkore International.
b. CANTEX INC.
c. Carlon; a brand of Thomas & Betts Corporation.
d. IPEX USA LLC.
e. PenCell Plastics.
f. Underground Devices, Inc.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.5 POLYMER CONCRETE HANDHOLES AND BOXES

2.6 Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armorcast Products Company.
2. Carson Industries LLC.
3. NewBasis.
4. Quazite: Hubbell Power System, Inc.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Green.

D. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, as indicated for each service (ELECTRIC and COMMUNICATION).

H. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.7 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast Group.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.

C. Comply with ASTM C 858.

D. Structural Design Loading: As indicated on drawing complying with AASHTO ratings.

E. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

F. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Splayed location.
2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie into concrete envelopes of duct.
4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches thick for future conduit entrance.

G. Ground Rod Sleeve: Provide a 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the duct entering the structure.

H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.8 ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BILCO Company (The).
2. Campbell Foundry Company.
3. Carder Concrete Products.
4. EJ Group, Inc.
5. Elmhurst-Chicago Stone Co.
6. McKinley Iron Works, Inc.
7. Neenah Foundry Company.
8. NewBasis.
9. Oldcastle Infrastructure Inc.; CRH Americas.
10. Osburn Associates, Inc.
11. Pennsylvania Insert Corporation.
12. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
13. Rinker Group, Ltd.
14. Riverton Concrete Products.
15. Underground Devices, Inc.
16. Utility Concrete Products, LLC.
17. Utility Vault Co.
18. Wausau Tile, Inc.

C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 48” opening with 22” smaller access centered in larger opening. Frame and cover shall have open pick hole and similar to Neenah Foundry #R-1740-F.

    a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

2. Cover Legend: Cast in. Selected to suit system.

    a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
    b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

    a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.
    b. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.
    c. Provide cast concrete grade rings without steps as needed to elevate cover to approximately 1” above finish grade. Cast iron adjusting rings may be used to trim final elevation.

D. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron. 14” diameter sump indentation located adjacent the manhole opening.

E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

A. Pulling-in and Lifting Irons in Concrete Wall and Floors: Eyebolt with reinforcing-bar fastening insert, minimum 2-inch-diameter eye, and 1-by-4-inch bolt. Hot-dipped galvanized pull-in irons mounted on the ceiling and on each wall. One removable pulling eye shall be installed in the floor, centered under the manhole opening.

F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

G. Ground Rod Sleeve: 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

B. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer having a combination high mechanical strength, thermal resistance, corrosion resistance and dielectric strength. Similar to Underground Devices Inc – CR36 w/ RA14/RA20.

1. Stanchions: Nominal two 36 inches high by 4 inches wide, with provisions to connect to other sections to form a continuous unit, with multiple holes for arm attachment.

2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be minimum capacity to 14 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties. Mounting hardware shall be 316 stainless steel.

I. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

J. Design Conditions:

1. Manholes shall be specifically designed for the following conditions and specifications.

Table 1

Design Conditions	
Item	**Criteria**
Ground water level	3’-6” below surface
Dry earth density	100 lbs./cu. ft.
Saturated earth density	120 lbs./cu. ft.
Live load	AASHTO H-20-S16 truck
Live load impact	2’-0” I = 20%
Earth cover	Min. 2’-0” – Max. 5’-0” for Electrical Manholes
F’c	4,500 P.S.I. with grade 60 reinforcing steel
Fy	60,000 P.S.I.
Codes & Standards	AASHTO Load factor design for manholes ASTM C-857 ACI Code 318 (USD) where applicable for man-holes

2.9 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Construction Manager if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by

coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Engineer.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 EARTHWORK

A. Excavation and Backfill: Ensure that the soil materials and compaction criteria used for the manhole conforms to the specifications and that the proper elevation for installation has been determined and verified prior to setting manhole.

B. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed. Contractor shall properly backfill and compact soil around the manholes after they have been inspected and approved.

3.3 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.

C. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

D. Bored Underground Duct: Type EPEC-40-HDPE unless otherwise indicated.

E. Underground Ducts Crossing Paved Paths, Walks, Driveways, and Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.

F. Stub-ups: Concrete-encased GRC.

3.4 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.

3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8 structural load rating.
4. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.5 EARTHWORK

A. Excavation and Backfill: Ensure that the soil materials and compaction criteria used for the manhole conforms to the specifications and that the proper elevation for installation has been determined and verified prior to setting manhole. .

B. Restoration: Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed. Contractor shall properly backfill and compact soil around the manholes after they have been inspected and approved.

C. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

3.6 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 12.5 feet, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of three 90 degree bends or the total of all bends shall be no more 270 degrees between pull points.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

K. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.

L. Concrete-Encased Ducts and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side if forms are used.
3. Width: Excavate trench 3 inches wider than duct on each side if the excavated walls are used as forms.
4. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.

    a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.

    b. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.

a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.

c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.
b. Place minimum 6 inches of engineered fill above concrete encasement of duct.

N. Warning Planks: Bury warning planks approximately 12 inches above direct-buried duct, placing them 24 inches o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

O. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.7 INSTALLATION OF CONCRETE MANHOLES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
3. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. ManholeLadder Access: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 071353 "Elastomeric Sheet Waterproofing." After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

F. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms as required for installation and support of cables and conductors and as indicated.

H. Fixed Manhole Access: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

I. Field-Installed Bolting Anchors in Manholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Division 260500-3.2 "Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: Through gyp board used EMT. Through concrete or block use galvanized rigid conduit (GRC).
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

    a. Thickness shall be minimum 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway for slabs-on-grade and below-grade-exterior walls.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Link-Seal

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel or Stainless steel.
4. Connecting Bolts and Nuts: Match material of pressure plates, of length required to secure pressure plates to sealing elements.

2.3 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in this section and Division 07 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide minimum 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. On communications sleeves where a raceway will NOT be installed within the sleeve, provide protect bushings on sleeve terminations.
6. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install steel pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 260544

SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Restraints - rigid type.
2. Restraints - cable type.
3. Restraint accessories.
4. Post-installed concrete anchors.
5. Concrete inserts.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.2 COORDINATION

A. Tests and Inspections:

1. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved) and provide notice at least seven days in advance.
2. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

1.3 SUBMITTALS

A. Product Data:

1. Restraints - rigid type.
2. Restraints - cable type.
3. Restraint accessories.
4. Post-installed concrete anchors.
5. Concrete inserts.

B. Shop Drawings: Show coordination of seismic and wind-load bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.

C. Delegated Design Submittal for Each Seismic-Restraint Device: Signed and sealed by qualified structural professional engineer.

1. For each seismic-restraint device, including restraint - rigid and cable type, restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:

a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by qualified testing laboratory for seismic reinforcement use.
c. Seismic Design Calculations: Submit input data and loading calculations prepared in accordance with criteria specified in Section 260011 "Facility Performance Requirements for Electrical."

D. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design seismic and wind-load control system in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 260011 "Facility Performance Requirements for Electrical."

B. Seismic-Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: ICC-ES product listing, UL product listing, FM Approvals, an agency acceptable to authorities having jurisdiction.

C. Consequential Damage: Provide additional seismic restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component does not cause failure of any other essential building component.

D. Fire/Smoke Resistance: Seismic- and wind-load-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested and labeled by qualified testing laboratory in accordance with ASTM E84 or UL 723.

E. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of qualified testing laboratory.

2.2 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CADDY; brand of nVent Electrical plc.
2. California Dynamics Corporation.
3. Cooper B-line; brand of Eaton, Electrical Sector.
4. Hilti, Inc.
5. Isolation Technology, Inc.
6. TOLCO Incorporated.
7. Unistrut; Atkore International.
8. VMC GROUP.

B. Description: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CADDY; brand of nVent Electrical plc.
2. Cooper B-line; brand of Eaton, Electrical Sector.
3. Gripple Inc.
4. Loos & Co. Inc.
5. VMC GROUP.

B. Seismic-Cables: ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.4 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CADDY; brand of nVent Electrical plc.
2. Cooper B-line; brand of Eaton, Electrical Sector.
3. Hilti, Inc.
4. Loos & Co. Inc.
5. Mason Industries, Inc.
6. TOLCO Incorporated.
7. Unistrut; Atkore International.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cooper B-line; brand of Eaton, Electrical Sector.
b. Hilti, Inc.
c. Mason Industries, Inc.
d. Powers Fasteners.
e. Unistrut; Atkore International.

2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Cooper B-line; brand of Eaton, Electrical Sector.
    b. Hilti, Inc.
    c. Mason Industries, Inc.
    d. Powers Fasteners.
    e. Unistrut; Atkore International.

2. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in seismic and wind-load applications.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

2.6 CONCRETE INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-line; brand of Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Powers Fasteners.
5. Unistrut; Atkore International.

B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.

C. Comply with MSS SP-58.

2.7 SOURCE QUALITY CONTROL

A. Product Data: Prepare and submit catalog cuts, brochures, diagrams, schedules, and performance data illustrating size, physical appearance, and other characteristics of product.

1. Include rated load capacity for each seismic-restraint device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

3. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by ICC-ES product listing or an agency acceptable to authorities having jurisdiction.
4. Annotate to indicate application of each product submitted and compliance with requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static, wind load, and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC-RESTRAINT CONTROL DEVICES

A. Provide seismic-restraint control devices for systems and equipment where indicated in Equipment Schedules or Seismic Controls Schedule, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

1. Install equipment and devices to withstand the effects of earthquake motions and high wind events.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of seismic restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.

D. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

F. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.

G. Install cables so they do not bend across edges of adjacent equipment or building structure.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.

B. Nonconforming Work:

1. Seismic controls will be considered defective if they do not pass tests and inspections.
2. Remove and replace malfunctioning units and retest as specified above.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

END OF SECTION 260548.16

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Bands and tubes.
3. Tapes and stencils.
4. Tags.
5. Signs.
6. Miscellaneous identification products.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

2. Arc Flash label for electrical equipment.

1.3 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 for color identification of hazards; 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs and tags; and the following:

1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.

D. Signs, labels, and tags required for personnel safety must comply with the following standards:

1. Safety Colors: NEMA Z535.1.
2. Facility Safety Signs: NEMA Z535.2.
3. Safety Symbols: NEMA Z535.3.
4. Product Safety Signs and Labels: NEMA Z535.4.
5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, must comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 1000 V or Less:
1. Black letters on white field for Normal Power. Red letters on white field for Standby Power. Label at every 25’.
2. Legend: Indicate voltage and system or service type.

B. Fire Alarm Conduit and Rough-ins Box
1. Junction boxes painted red. Device address will be red letters on white field on junction box cover.
2. Colored Raceway and boxes (Red).
3. Legend: FA System, and Device address.

C. Armored and Metal-Clad cable

1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
2. Black letters on white field for Utility Power. Red letters on White field for Standby Power.
3. Legend: Indicate voltage and system or service type.

D. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

1. Color must be factory applied or field applied for sizes larger than 8 AWG if authorities having jurisdiction permit.
2. Where two or more neutrals are included in same conduit, at each panel, junction box, etc. the proper neutral wire shall be permanently and effectively identified with its branch circuit conductor(s) taped together and labeled with circuit number(s). The neutrals shall have a colored strip that corresponds to the phase color of the non-grounded conductor.
3. For branch circuit conductors, wiring shall be identified with wrap-on wire vinyl cloth wire markers. Number shall indicate associated terminal in motor controller, panel board, etc.
4. Phase sequence shall be N-A-B-C, proceeding in direction of left to right, front to back, top to bottom. All phase and neutral shall be identified.
5. All feeder to power distribution equipment and to all motors shall be completely phase out as to sequence and rotation and so labeled.
6. For renovation project color coding shall match to existing in the building.
7. For new construction color coding shall be as shown in the table below:

ITEM	120/208	277/480
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
“A” Phase Neutral	White with Black Tracer	Gray with Brown Tracer
“B” Phase Neutral	White with Red Tracer	Gray with Orange Tracer
“C” Phase Neutral	White with Blue Tracer	Gray with Yellow Tracer
Shared Neutral	White with No Tracer	Gray with No Tracer
Switch Leg Return	Yellow	Yellow
Three and Four Way “Travelers	Orange	Orange
Mechanical or Equipment Ground Only	Green	Green

8. Colors for 240 V Circuits:

a. Phase A: Black.
b. Phase B: Red.

E. Raceways and Cables Carrying Circuits at More Than 1000 V:

1. Black letters on orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

F. Warning Label Colors:

1. Identify system voltage with black letters on orange background.

G. Warning labels and signs must include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."

H. Equipment Identification Labels:

1. Black letters on white field for Normal Power. Red letters on White field for Standby Power.

2.3 LABELS

A. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Minimum Nominal Size:

a. 1-1/2 by 6 inch for raceway and conductors.
b. 3-1/2 by 5 inch for equipment.
c. As required by authorities having jurisdiction.

B. For arc-flash labels, coordinate with Section 260574 "Overcurrent Protective Device Arc-Flash Study".

2.4 BANDS AND TUBES

A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch long, with diameters sized to suit diameters and that stay in place by gripping action.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at maximum of 200 deg F. Comply with UL 224.

2.5 TAPES AND STENCILS

A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil thick by 1 to 2 inch wide; compounded for outdoor use.

B. Tape and Stencil: 4 inch wide black stripes on 10 inch centers placed diagonally over orange background and are 12 inch wide. Stop stripes at legends.

C. Floor Marking Tape: 2 inch wide, 5 mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

D. Underground-Line Warning Tape:
   1. Tape:

      a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical and communications utility lines.
      b. Printing on tape must be permanent and may not be damaged by burial operations.
      c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

   2. Color and Printing:

      a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.
      b. Inscriptions for Red Tapes: "CAUTION BURIED ELECTRIC LINE BELOW".
      c. Inscriptions for Orange Tapes: "CAUTION BURIED COMMUNICATION LINE BELOW".

      a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
      b. Width: 3 inch.
      c. Thickness: 12 mil.
      d. Weight: 36.1 lb/1000 sq. ft.
      e. Tensile in accordance with ASTM D882: 400 lbf and 11,500 psi.

E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height must be 1 inch.

2.6 TAGS

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

B. Write-on Tags:

1. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
2. Marker for Tags:

    a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
    b. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:
1. Engraved legend.
2. Thickness:

    a. For signs up to 20 sq. inch, minimum 1/16 inch thick.
    b. For signs larger than 20 sq. inch, 1/8 inch thick.
    c. Engraved legend with black letters on white face.
    d. Self-adhesive.
    e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 1000 V: Identification must completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Emergency Operating Instruction Signs: Install instruction signs with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

L. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:

1. "EMERGENCY POWER AND CIRCUIT."
2. "UTILITY POWER AND CIRCUIT."
3. "UPS POWER AND CIRCUIT."
4. System legends shall be as follows: See drawing sheets for panel and equipment schedules for naming.

M. Self-Adhesive Labels:

1. Install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high label; where two lines of text are required, use labels 2 inch high.

N. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.

O. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.

P. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.

Q. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.

R. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

S. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.

T. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inch below finished grade. Use multiple tapes where width of multiple lines installed in common trench or concrete envelope exceeds 16 inch overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

U. Nonmetallic Preprinted Tags:

1. Place in location with high visibility and accessibility.
2. Secure using UV-stabilized or plenum-rated cable ties.

V. Write-on Tags:

1. Place in location with high visibility and accessibility.
2. Secure using UV-stabilized or plenum-rated cable ties.

W. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on minimum 1-1/2 inch high sign; where two lines of text are required, use signs minimum 2 inch high.

X. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high sign; where two lines of text are required, use labels 2 inch high.

Y. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways, Armored and Metal-Clad Cables, More Than 1000 V: Self-adhesive labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.

D. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.

E. Accessible Fittings for Raceways and Cables within Buildings: Identify cover of junction and pull box of the following systems with self-adhesive labels containing wiring system legend and system voltage. System legends must be as follows:

1. “NORMAL POWER.”
2. “GENERATOR POWER.”
3. "EMERGENCY POWER."
4. "UTILITY POWER."
5. "UPS POWER."
6. “FIRE ALARM SYSTEM”

F. Conductors to Be Extended in Future: Attach write-on tags to conductors and list source.

G. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

H. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

I. Concealed Raceways and Duct Banks, More Than 1000 V, within Buildings: Apply floor marking tape to the following finished surfaces:
   1. Wall surfaces directly external to raceways concealed within wall.
   2. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in building.

J. Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.

K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.

   1. Apply to exterior of door, cover, or other access.
   2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

      a. Power-transfer switches.
      b. Controls with external control power connections.

L. Arc Flash Warning Labeling: Self-adhesive labels.

M. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

N. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.

O. Equipment Identification Labels:

   1. Indoor Equipment: Self-adhesive label.
   2. Outdoor Equipment: Laminated acrylic or melamine sign.
   3. Equipment to Be Labeled:

      a. Panelboards:
         1) Typewritten directory of circuits in the location provided by panelboard manufacturer.
            a) 5”x8” minimum size protected by plastic sleeve or guard, Example: “Room 204 – outlets – North wall”.
         2) Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
            a) 1/2" high letters on outside of panel doors identifying panel, voltage, phase, wire, and source of feed. Label Interior of panel using marker, Example: “LNP1, 208Y/120V, 3-Phase, 4W, LDP-1, Circuit #4”.
         3) Arc-flash label comply with NFPA 70 E and /or specified.
      b. Enclosures and electrical cabinets.
      c. Access doors and panels for concealed electrical items.

d. Switchgear, Switchboard, Substation and Power Panel (Dist Board):
   1) Provide an engraved plastic label with 3/4" high letters, security attached, identifying the unit, voltage, phase, and wire, Example: “MDP-1, 208Y/120V, 3-Phase, 4W”.
   2) Branch switches to be labeled with engraved plastic label with 3/16” high letters securely attached to exterior of device. Example “Pump HWP1”.
   3) Label to include the name of the load it is feeding and with the source of the power, Example: “SD-P fed from MD-P, located in room #B64.”
   4) Arc-flash label comply with NFPA 70 E and /or specified.
e. Transformers:
   1) Provide an engraved plastic label with 3/4" high letters, security attached, identifying the unit, voltage, phase, and wire, Example: “TN1”, Feed from “MDP-1, and Feed to LDP-1”.
f. Emergency system boxes and enclosures.
g. Enclosed switches, Enclosed circuit breakers, Enclosed controllers, Variable-speed controllers, Contactors, Battery-inverter units, UPS equipment:
   1) Label each with engraved plastic label with 3/16” high letters securely attached to the exterior of device as follows: Equipment served, Source of feed and circuit number, Example: “ACP-20 fed from SD-P-1 located in room #B64”.
   2) Arc-flash label comply with NFPA 70 E and /or specified.
h. Power-transfer equipment (ATS):
   1) Label “Normal” and “Emergency” poles with engraved plastic tag.
   2) Label transfer switches with source designations as “Normal Switchboard SD-P” or “Emergency-Source”.
   3) Arc-flash label comply with NFPA 70 E and /or specified.
i. Remote-controlled switches, dimmer modules, and control devices:
      a) Utility (Normal) power device covers shall be marked with a clear label with black lettering indicating panel and circuit, Example: “Panel PR2-B4, Cir. # 3”
      b) Emergency power device covers shall be marked with a clear label with red lettering indicating panel and circuit, Example: “Panel ER2-B4, Cir. # 3”
j. Battery-inverter units.
   1) Provide an engraved plastic label with ¾” high letters, securely attached, identifying the unit, voltage, phase, and wire:
      a) Example: Feed from “P-L-1.1, Cir#1”.
k. Power-generating units:
   1) Provide an engraved plastic label with 3/4" high letters, security attached, identifying the unit, voltage, phase, and wire, Example: “GEN-1, XXX KW, 13.2KV, 3-Phase”.

END OF SECTION 260553

SECTION 260573.13 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, fault-current study to determine minimum interrupting capacity of circuit protective devices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.
4. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 DEFINITIONS

A. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

E. Single-Line Diagram: See "One-Line Diagram."

1.3 SUBMITTALS

A. Product Data:

1. For power system analysis software to be used for studies.

B. Short-Circuit Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals mustbe in digital form.

a. Short-circuit study input data, including completed computer program input data sheets.
b. Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

C. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

D. Provide an electronic backup copy of the SKM completed model and SKM libraries used for the model.

1.4 QUALITY ASSURANCE

A. Study must be performed using SKM Power Tools developed and distributed software designed specifically for power system analysis.

B. Software algorithms must comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

A. SKM Power Tools

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of power systems analysis software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output.

E. Computer program must be designed to perform short-circuit studies or have function, component, or add-on module designed to perform short-circuit studies.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
6. Derating factors and environmental conditions.
7. Any revisions to electrical equipment required by study.

D. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.
4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Medium Voltage and Low-Voltage Fault Reports: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Calculated asymmetrical fault currents:

1) Based on fault-point X/R ratio.
2) Based on calculated symmetrical value multiplied by 1.6.
3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

A. Obtain data necessary for conduct of study.

1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Engineer's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate required input data to support short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
11. Derating factors.

3.2 SHORT-CIRCUIT STUDY

A. Perform study following general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.
2. Exclude equipment supplied by single transformer smaller than 75 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

H. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

I. Include in report identification of protective device applied outside its capacity.

J. Provide an electronic backup copy of the SKM completed model and SKM libraries used for the model.

END OF SECTION 260573.13

SECTION 260573.16 - COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.13 "Short-Circuit Studies" for fault-current studies.
4. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 DEFINITIONS

A. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when abnormal current flow exists and then removes the affected portion of the circuit from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

E. Single-Line Diagram: See "One-Line Diagram."

1.3 SUBMITTALS

A. Product Data:

1. For power system analysis software to be used for studies.

B. Coordination Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals **must**be in digital form.

a. Coordination-study input data, including completed computer program input data sheets.
b. Study and equipment evaluation reports.
c. Revised one-line diagram, reflecting field investigation results and results of coordination study.

C. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

D. Provide an electronic backup copy of the SKM completed model and SKM libraries used for the model.

1.4 QUALITY ASSURANCE

A. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms must comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

A. SKM Power Tools

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

E. Computer program must be designed to perform coordination studies or have function, component, or add-on module designed to perform coordination studies.

2.2 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Revisions to electrical equipment required by study.
7. Study Input Data: As described in "Power System Data" Article.

a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

D. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.

a. Phase and Ground Relays:

1) Device tag.
2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:

1) Adjustable pickups and time delays (long time, short time, and ground).
2) Adjustable time-current characteristic.
3) Adjustable instantaneous pickup.
4) Recommendations on improved trip systems, if applicable.

c. Fuses: Show current rating, voltage, and class.

E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying portion of system covered.
2. Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
3. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

   a. Power utility's overcurrent protective device.
   b. Medium-voltage equipment overcurrent relays.
   c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   f. Cables and conductors damage curves.
   g. Ground-fault protective devices.
   h. Motor-starting characteristics and motor damage points.
   i. Generator short-circuit decrement curve and generator damage point.
   j. Largest feeder circuit breaker in each motor-control center and panelboard.

5. Maintain selectivity for tripping currents caused by overloads.
6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
7. Provide adequate time margins between device characteristics such that selective operation is achieved.
8. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Obtain data necessary for conduct of overcurrent protective device study.

1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies to Engineer's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate required input data to support coordination study. List below is guide. Comply with recommendations in IEEE 551 for amount of detail required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).

17. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
    k. Identify series-rated interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.3 COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin analysis at service, extending down to system overcurrent protective devices as follows:

    1. To normal system low-voltage load buses where fault current is 5 kA or less.
    2. Exclude equipment supplied by single transformer smaller than 75 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device must not operate in response to the following:

a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings must protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's instructions and to IEEE 242.

K. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

L. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Include in report identification of protective device applied outside its capacity.

3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform load-flow and voltage-drop study to determine steady-state loading profile of system. Analyze power system performance two times as follows:

1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load flow and voltage drop based on 80 percent of design capacity of load buses.
3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.5 MOTOR-STARTING STUDY

A. Perform motor-starting study to analyze transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze effects of motor starting on power system stability.

B. Prepare motor-starting study report, noting light flicker for limits proposed by IEEE 141, , and voltage sags so as not to affect operation of other utilization equipment on system supplying motor.

3.6 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.

B. Provide recommended modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting must be by qualified medium-voltage and low-voltage electrical testing and inspecting agency.

END OF SECTION 260573.16

SECTION 260573.19 - ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, arc-flash study to determine arc-flash hazard distance and incident energy to which personnel could be exposed during work on or near electrical equipment.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.13 "Short-Circuit Studies" for fault-current studies.
4. Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.

1.2 DEFINITIONS

A. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. p.u.: Per unit. The reference unit, established as a calculating convenience, for expressing all power system electrical parameters on a common reference base.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

F. Single-Line Diagram: See "One-Line Diagram."

1.3 SUBMITTALS

A. Product Data:

1. For power system analysis software to be used for studies.

B. Study Submittals:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form:

a. Arc-flash study input data, including completed computer program input data sheets.
b.
c. Revised one-line diagram, reflecting field investigation results and results of arc-flash study.

C. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

D. Provide an electronic backup copy of the SKM completed model and SKM libraries used for the model.

1.4 QUALITY ASSURANCE

A. Study must be performed using SKM Power Tools developed and distributed software designed specifically for power system analysis.

B. Software algorithms must comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. SKM Power Tools

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer program must be designed to perform arc-flash analysis or have function, component, or add-on module designed to perform arc-flash analysis.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings, including derating factors and environmental conditions.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

G. Arc-Flash Study Output Reports:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Restricted approach boundary.
6. Limited approach boundary.
7. Working distance.

8. Incident energy.
9. Hazard risk category.
10. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce 3.5 by 5 inch (76 by 127 mm) self-adhesive equipment label for each work location included in analysis.

B. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Protection boundaries.
    a. Arc-flash boundary.
    b. Restricted approach boundary.
    c. Limited approach boundary.
4. Arc flash PPE category.
5. Required minimum arc rating of PPE in Cal/cm squared.
6. Available incident energy.
7. Working distance.
8. Engineering report number, revision number, and issue date.

C. Labels must be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies: Perform Short-Circuit and Protective Device Coordination studies prior to starting Arc-Flash Hazard Analysis.

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

C. Calculate maximum and minimum contributions of fault-current size.

1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current in accordance with NFPA 70E recommendations.

D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment fed from transformers smaller than 75 kVA.

F. Calculate limited, restricted, and prohibited approach boundaries for each location.

G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must take into account changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:

1. Fault contribution from induction motors must not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).

H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:

1. When circuit breaker is in separate enclosure.
2. When line terminals of circuit breaker are separate from work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain data necessary for conduct of arc-flash hazard analysis.

1. Verify completeness of data supplied on one-line diagram on Drawings. Call discrepancies to Engineer's attention.
2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to amount of detail that is required to be acquired in field. Field data gathering must be under direct supervision and control of engineer in charge of performing study, and must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance or available short circuit current at service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage conductor sizes, lengths, conductor material, conductor construction and metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).

3.4 LABELING

A. Apply one arc-flash label on front cover of each section of equipment included in study. Base arc-flash label data on highest values calculated at each location.

B. Each piece of equipment listed below not fed by single transformer smaller than 75 kVA must have arc-flash label applied to it:

1. Medium-voltage switchgear.
2. Medium-voltage switches.
3. Medium voltage transformers.
4. Low-voltage switchgear.
5. Switchboards.
6. Panelboards.
7. Motor-control centers.
8. Low voltage transformers.
9. Safety switches.
10. Control panels.
11. Automatic transfer switches.
12. UPS
13. Generator
14. VFD and Motor controls.

C. Note on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.

END OF SECTION 260573.19

SECTION 260580 – EQUIPMENT WIRING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes providing electrical connections to equipment furnished under other Specification Sections and/or the Owner such as overhead doors, door access and control equipment, modular furniture, elevators, HVAC equipment, plumbing equipment, etc.

1.3 GENERAL REQUIREMENTS

A. Provide all required labor, material, equipment, and Contractor’s services necessary to complete the electrical portion of the equipment installation.

B. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, manufacturer's instructions, etc., for equipment furnished under other sections or by the Owner. Coordinate with equipment suppliers to determine connection locations and all other electrical requirements.

C. All electrical requirements for equipment furnished under other Specification Sections and/or the Owner to be connected may not be shown on the electrical drawings. Review all project specifications and drawings for all such equipment requirements prior to bid.

D. Verify all equipment requirements with the Contractor and/or the Owner who is providing the equipment including approved submittals prior to rough-in. Make adjustments in any electrical equipment, devices, etc. shown on the drawings as required to properly connect equipment.

E. The Contractor supplying the equipment is responsible for the correct locations of all equipment provided by the Contractor. The Owner is responsible for the correct locations of all equipment provided by the Owner.

PART 2 - PRODUCTS

2.1 Provide electrical equipment, disconnects, devices, wiring, etc. as specified under other Division 26 specification sections unless otherwise noted.

2.2 Cords, Plugs and Receptacles

A. Cord Construction: Oil-resistant thermoset insulated Type SO multi-conductor flexible cord with identified equipment grounding conductor, suitable for extra hard usage.

B. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

C. Attachment Plug Configuration: Match receptacle configuration at outlet furnished for equipment.

D. Verify overcurrent protection requirements and verify the NEMA rating of plugs and receptacles.

PART 3 - EXECUTION

3.1 INSPECTION

A. Verify that equipment is ready for electrical connection, wiring, and energizing.

3.2 PREPARATION

A. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

3.3 INSTALLATION

A. Provide all raceway, pathways, flexible conduit for movable equipment, wiring, circuit breakers, fuses, safety switches, motor starters, motor starter interlocks, push-button stations, remote stations, indicating lights, control devices such as limit switches, etc. as required to properly connect the equipment for complete and operational system.

B. Make electrical connections of all equipment, devices, circuits, wiring, etc. Make these connections in control panels or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions.

C. For electrical equipment and devices furnished by other contractors that is located in or on casework and built-in furniture: provide conduit, fittings, boxes and wiring ahead of the electrical equipment and devices to make the electrical connections.

D. Provide a minimum 1” conduit skeletal raceway system to house all card access and door hardware system low-voltage cabling. Refer to Section 260533 for additional skeletal raceway requirements.

E. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.

F. Provide prefinished cord set and receptacle where connection with attachment plug is indicated or specified.

G. Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connections boxes.

H. The Contractors responsible for other Specification Sections and the Owner are to provide manufacturer's wiring diagrams to this Contractor for equipment furnished by them.

END OF SECTION 260580

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify Division 26 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in Section 019113.

C. Commissioning requires the participation of Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Division 1. Division 26 shall be familiar with all parts of Division 1 and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 019113 – Commissioning Requirements.

B. Section 019114 – Installation Verification Procedures

C. Section 019115 – Functional Test Procedures

D. Section 017913 – Demonstration and Training Requirements

1.3 SUBMITTALS

A. Refer to Division 01 and Section 019113 for commissioning submittal requirements. Provide copies of commissioning submittal requirements to the CxA in addition to copies required by the Owner and Design Professional.

1.4 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 019113 for definitions and abbreviations used in this section.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 26 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 019113 for additional equipment requirements.

PART 3 - EXECUTION

3.1 COMMISSIONING

A. General Requirements: For additional information regarding general commissioning requirements refer to Section 019913.

B. Installation contractors shall be responsible for executing and documenting equipment installation, startup and check out of systems and equipment prior to CxA scheduling the functional performance tests. Contractor shall al be responsible for providing training of the Owner's maintenance personnel in accordance with requirement of Division 01.

C. Installation verification checklist for the commissioned systems and equipment shall be provided to the installation contractors by the CxA for use by the contractor in documenting the installation and startup of equipment in the commissioning process.

D. For systems and equipment components requiring a manufacturer’s representative for installation and startup, the installing contractor is responsible for attaching the startup report to the IVC provided by the CxA.

E. TAB reports required for the plumbing systems shall be provided to the CxA before functional testing is started.

3.2 GENERAL RESPONSIBILITIES

A. The commissioning responsibilities applicable to each of the electrical contractors in regards to Division 26 are as follows

1. Include the cost of commissioning in the contract price.
2. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
3. Ensure acceptable representation with the means and authority to assist the CxA in the coordination and execution of the commission process.
4. Attend a commissioning scoping meeting and other meetings necessary to facilitate the Commissioning process.
5. Review commissioning plan to be provided by the CxA.
6. Assist CxA with developing a comprehensive commissioning schedule during regularly scheduled commissioning meetings.
7. Complete commissioning activities as scheduled in the master construction schedule.
8. Submit completed IVC checklists and supporting documents to PM/CM. The contractor with primary responsibility to provide and install the system or equipment is responsible for ensuring that other contractors involved with the installation complete their portion of the checklist.
9. Ensure that installation and startup are complete and the system or equipment are ready for functional testing.

10. Utilize the FPT protocols to retest the system or equipment prior to actual function performance testing. Provide documentation to CxA that pretesting was performed.
11. Address current A/E punch list items before functional testing.
12. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
13. Provide skilled technicians to perform functional performance testing under the direction of the Commissioning Authority.
14. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, OPM and A/E and retest the equipment.
15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to record conditions.
16. Provide training of the Owner's maintenance and operating staff using expert qualified personnel, as specified.
17. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

B. With respect to HVAC commissioning, the electrical contractor shall:

1. Include cost to assist the Division 23 contractor commission of the HVAC and Plumbing systems and equipment that are part of the commissioning program.
2. Review design with respect to providing power to the HVAC and Pluming systems.
3. Schedule work so that required electrical installations are completed and systems verification checks and functional tests can be carried out on schedule.
4. Using the IVC and other startup report documentation, inspect check and confirm in writing the proper installation and performance of all electric services for mechanical systems and equipment for in the commissioning program.

3.3 TRAINING

A. Refer to Section 017913 – Demonstration and Training for training requirements.

B. Contractor responsible for the installation of the system shall coordinate the participation of other sub-contractors and manufacturer's representatives in the training program.

END OF SECTION 260800

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Indoor occupancy and vacancy sensors.
4. Switchbox-mounted occupancy and vacancy sensors
5. High-bay occupancy and vacancy sensors.
6. Lighting contactors.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Tork.
2. Intermatic, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lutron.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: DPST.
3. Contact Rating: 30-A inductive or resistive, 240-V ac.
4. Programs: Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
6. Astronomic Time: All channels.
7. Automatic daylight savings time changeover.
8. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Tork

2. Intermatic, Inc.

B. Description: Solid state, with SPST dry contacts rated for 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen-second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
6. Failure Mode: Luminaire stays ON.

2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Leviton Manufacturing Co., Inc.
2. Lutron Electronics Co., Inc.
3. Hubbell Control Solutions; Hubbell Incorporated, Lighting.

B. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn

them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet when mounted 96 inches above finished floor.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Control Solutions; Hubbell Incorporated, Lighting.
2. Leviton Manufacturing Co., Inc.
3. Lutron Electronics Co., Inc.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800-VA LED load at 120 V.

C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: 120 V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White.
11. Faceplate: Color matched to switch.

2.5 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Eaton.
2. Leviton Manufacturing Co., Inc
3. Square D.
4. ABB (Electrification Products Division)

B. Description: Electrically operated and electrically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.6 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

D. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

E. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's written instructions.

C. Size conductors in accordance with lighting control device manufacturer's written instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 261116.11 - SECONDARY UNIT SUBSTATIONS WITH SWITCHGEAR SECONDARY – EQUIPMENT PURCHASE.

PART 1 - GENERAL

1.1 SUMMARY

A. Unit Substations to be purchased:

1. USS-MECH-01 – 3000KVA, 80 deg C AA / 133% FA rated, 13,200V delta to 480/277V wye, Cast Coil, Main-Tie-Main distribution switchgear. Fused 15KV duplex interrupter primary switch.
2. USS-MECH-02 – 3000KVA, 80 deg C AA / 133% FA rated, 13,200V delta to 480/277V wye, Cast Coil, Main-Tie-Main distribution switchgear. Fused 15KV duplex interrupter primary switch.
3. ESS-CUP-01 – 2000KVA, 80 deg C AA / 133% FA rated, 13,200V delta to 480/277V wye, Cast Coil, Single ended Main distribution switchgear. Fused 15KV duplex interrupter primary switch.

B. Section Includes:

1. Manufactured units.
2. Medium-voltage metal-enclosed switchgear section.
3. Medium-voltage instruments section.
4. Dry-type transformer section.
5. Secondary distribution section switchgear.
6. Low-voltage instrument section.
7. Includes HMI Dashboard as specified in section 262300.01.

C. Drawings: EP-504, EP-701, EP-704, EP705 and EP-708.

1.2 DEFINITIONS

A. BIL: Basic Insulation Level.

B. L.A.: Lightning Arrester.

C. MVA: Megavolt Ampere.

D. NETA ATS: Acceptance testing specification.

E. PCB: Polychlorinated biphenyl.

F. RTD: Resistance temperature detector (IEEE C37.2 Device No. 26).

G. SCR: Silicon Controlled Rectifier.

H. SPD: Surge Protective Device.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

a. Differentiate between manufacturer-installed and field-installed wiring.
b. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

2. Dimensioned plans and elevations showing major components and features.

a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
b. Identify center of gravity and locate and describe mounting and anchorage provisions.

3. One-line diagram.
4. List of materials.
5. Nameplate legends.
6. The material, size and number of bus bars, and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
7. Short-time and short-circuit current ratings of secondary unit substations and components.
8. Enclosed bus duct details.
9. Accessory information for items such as circuit breaker test set, breaker remote racking assembly, breaker lifting cart, yoke and spare equipment storage cabinet.
10. Type and Ratings of individual protective devices.
11. CT, PT and LA (lightning Arrestor) sizes.
12. RC Snubber sizing and information.
13. Mimic-bus diagram.
14. Provide dimensioned drawings and details for the HMI/OIT standalone remote cabinet.
15. Provide spreadsheet table form list identifying all the metering and status points for interrupter switches, transformers, gear devices and breakers. In table include columns for communication method and connection to locations (gear internal, remote HMI/OIT, SCADA and BMS).

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

E. Field quality-control reports.

F. Product Certificates: For secondary unit substations, signed by product manufacturer.

G. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

H. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

I. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

J. Factory test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1. In addition to "Operation and Maintenance Data," include the following:

    a. Lists of spare parts and replacement components recommended for storage at Project site.
    b. Detailed instructions covering operation under both normal and abnormal conditions.
    c. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.
    d. Spreadsheet table list with addressing for each metering and status point.

2. Software and Firmware Operational Documentation: Provide PDF files on a USB storage device.

    a. Software operating and upgrade manuals.
    b. Program Software Backup, complete with data files.
    c. Device address list.
    d. Printout/Screen Shots of software application and graphic screens.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Six of each type and rating of fuse and fusible device used, except for medium-voltage fuses. Include spares for the following:

    a. Primary disconnect fuses.
    b. Potential transformer fuses.
    c. Control power fuses.
    d. Fuses for secondary fusible devices.

2. Spare Indicating Lights: Six of each type installed.
3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
4. Primary Switch Contact Lubricant: One container(s).

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Can be one or combination of both.

1. Member company of NETA or NRTL.

    a. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

2. Manufacturer certified field service technician.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with install contractor to deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate with install contractor for delivery of secondary unit substations to allow movement into designated space.

C. Coordinate with install contractor for offloading requirements at destination.

D. Provide manufacturer's temporary heating requirement and written instructions to installing contractor.

E. Provide manufacturer's written instructions to handle secondary unit substation components. Provide factory-installed lifting provisions.

F. Provide transportation shock recorders and tilt indicators with each shipping split. Provide written tolerance requirements for each indicator type.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding 104 deg F (40 deg C).

1.9 WARRANTY

A. Manufacturer's Warranty Period: Manufacturer's maintenance and service organization shall provide a warranty of five (5) years from date of startup commissioning. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include required system hardware, software and programming updates.

E. Warranty shall include coverage for labor, material and expense costs to correct all defects.

F. Warranty requirements specified in the Owner's contract documents which are more stringent than those listed in this specification shall override these requirements.

G. Original equipment repair parts shall be available for a minimum of 10 years.

1.10 START-UP

A. Provide manufacturer certified field service technician(s) required for a complete installation. To include field programming adjustments, breaker/protection relay setting adjustments, start up, field quality control and commissioning of equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ABB (G.E.)

B. Eaton

C. Schneider Electric, Square D

D. Siemens

2.2 SYSTEM DESCRIPTION

A. Description: Medium-voltage, primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers, fusible switches, and metering components.

1. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Comply with IEEE C2.
3. Comply with IEEE C37.121

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The secondary unit substations shall withstand the effects of earthquake motions determined according to ASCE/SEI 7**.**

1. The term "withstand" means "the secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified and the secondary unit substation will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

2.4 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Separate secondary distribution equipment connected with busway.

B. Connections between primary device and transformer must be bus, and between transformer and secondary must be flexible bus braid unless noted otherwise.

C. Indoor Enclosure: Steel.

D. Unit Substation Enclosures Finish:

1. Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 MEDIUM-VOLTAGE METAL-ENCLOSED SWITCHGEAR SECTION

A. Metal-enclosed, air-interrupter switchgear, with fuses, complying with IEEE C37.20.3.

B. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.

1. System Voltage: 13.2kV nominal; 15kV maximum.
2. Design Level of Available-Source Fault Current: 25kA Symmetrical.
3. Main-Bus Rating: 600A, continuous.

C. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.

1. Rating: 600A continuous duty and load break.
2. Two-Time Duty-Cycle Fault Closing: 40 000A, asymmetrical.
3. Switch Action: No external arc and no significant quantities of ionized gas released into enclosure.
4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
6. Protective Shields: Cover live components and terminals.

    a. Fuse Mounts: Single-frame mounted and de-energized when switch is open.

7. Mechanical Interlock: Prevent opening of switch compartment door unless switchblades are open, and prevent closing switch if door is open. Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
8. Window: Permits viewing switchblade positions when door is closed.
9. Rear cabinet door shall be hinged, provided with three-point latch mechanism operated by a 180-degree handle with padlock able hasp.
10. IR window ports aligned with cable terminations on rear cable compartment door.
11. Ground bus shall include a grounding ball stud, with removable insulated cover.

D. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.

1. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
2. Indicator integral with each fuse to show when it has blown.
3. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

E. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

F. R.C. Snubber Circuit: Comply with IEC 60871-1, ANSI / IEEE Standard 18 NEMA CP-1.

1. R.C. Snubber Circuit may be installed in the Switch cabinet or as part of the Transformer.

2.6 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.51, and dry-type, two-winding, secondary unit substation transformer.

B. Style:

1. Indoor, ventilated, cast coil/encapsulated coil, with primary and secondary copper windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 104 deg F (40 deg C).

C. Cooling System:

1. Class AFA, forced-air cooling, complying with IEEE C57.12.01.

a. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.

1) High-Temperature Alarm: Part of controls at transformer with local audible and visual alarm and contacts for remote alarm.

b. Include cooling fans.
c. Provide power for the controls from a separate control power transformer in the transformer section or from control power in the distribution section.
d. Controls Communication: Unit shall be equipped for remote monitoring. Using Modbus TCP/IP over Ethernet.

D. Insulation Materials: IEEE C57.12.01, rated 220 deg C.

1. Insulation Temperature Rise: 80 deg C, maximum rise above 104 deg F (40 deg C).

E. BIL: 95 kV.

F. Full-Capacity Voltage Taps:

1. Four nominal 2.5 percent taps, two above and two below rated primary voltage.

G. R.C. Snubber Circuit: Comply with IEC 60871-1, ANSI / IEEE Standard 18 NEMA CP-1.

1. R.C. Snubber Circuit may be installed in the Switch cabinet or as part of the Transformer.

H. Transformer enclosure side panels shall be hinged with captive bolts to secure the panels to the enclosure frame.

I. IR window ports aligned with cable terminations on the side panels.

2.7 480/277V SECONDARY DISTRIBUTION SECTION SWITCHGEAR

A. The secondary distribution section must be electrically operated draw-out, low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558.

1. Section barriers between main, tie and feeder circuit-breaker compartments must be extended to rear of section.

B. Switchgear Capacities and Characteristics

1. Nominal System Voltage: 480/277V three phase, four wire.
2. Rated Power Frequency: 60 Hz.
3. Rated Insulation Level: Power frequency withstand shall be not less than 2.2-kV rms.
4. Rated Continuous Current:

a. Main Bus Continuous:

1) USS-Mech-01 – 5000 A
2) USS-Mech-02 – 5000 A
3) ESS-CUP-01 – 3200 A

b. Main-Bus Continuous: Shall be accomplished without the use of limiter fuses.
c. Vertical Section Bus Riser: Equal to the frame size of the low-voltage power circuit breaker connected to that riser.
d. Rated Short-Circuit Withstand Current: Minimum 100,000 A symmetrical fully rated system unless noted otherwise on schedule.
e. Short-Time and Short-Circuit Current: Match rating of integrated short-circuit current rating.
f. Series rated system shall not be acceptable.
g. Provide remote (HMI/OIT) to display all switchgear parameter, one line, operation and monitoring function, refer to section 2.7,F, for additional scope.

C. Switchgear Structure:

1. Match and align front and back of switchgear.
2. Sections should be a minimum of 22”, 30”, or 44” wide, respectively, dependent on the circuit breaker frame size being installed.
3. Total switchgear depth base is 80” (2052mm) minimum. Depth dependent on the number of raceways required for circuit breaker frame size being installed.
4. Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.

5. Allow the following circuit-breaker functions to be performed when compartment door is closed:

    a. Operate manual charging system.
    b. Open and close circuit breaker.
    c. Examine and adjust trip unit.
    d. Read breaker nameplate.

6. Locate instrumentation transformers within breaker cell and make front accessible and removable.
7. Install instrument compartments when additional space is required for metering and instrumentation. Allow for routing of instrumentation, control and communications wires, and cables.
8. The switchgear assembly shall consist of one or more enclosed vertical sections. Each vertical section shall contain up to four high individually enclosed breakers with uniformed height or instrument compartment and a full-height rear compartment housing the buses and outgoing cable connections.
9. The basic structure shall provide a rigid platform based on a C-channel design. The structure shall be comprised of 12 and 14-gauge galvanized steel.
10. Floor plates running from front to rear of the switchgear base to be supplied with removable conduit cutout for power and control wiring.
11. Four lifting eyes shall be provided on the roof of every shipping split.
12. Rear doors shall be hinged, provided with three-point latch mechanism operated by a 180-degree handle with a padlock able hasp.
13. Front doors are strengthened with three-point door latches.
14. Each circuit breaker shall be mounted in its own individual-barrier, grounded compartment.
15. Electrical meter shall be mounted in its own individual-barrier, grounded compartment.
16. SPD shall be mounted in its own individual-barrier, grounded compartment with circuit disconnect.
17. Infrared Window: Each breaker rear cable connection stabs shall contain round window ports. The ports shall be 4”. The window ports quantity and locations for each breaker must be positioned to provide optimal viewing with external infrared camera.

D. Switchgear Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity the entire length of section.
3. Neutral Bus: 100 percent of phase-bus ampacity.
4. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
5. Phase- and Neutral-Bus Material:

    a. Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.

6. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
7. Contact Surfaces of Buses: Silver plated.
8. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
9. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inch (6 by 50 mm).
10. Provide grounding ball stud with removable insulation cover in each rear cabinet section for connection of safety grounds.
11. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
12. Neutral Disconnect Link: Bolted, uninsulated, 1/4 by 2 inch (6 by 50 mm) copper bus, arranged to connect neutral bus to ground bus.
13. Bus-Bar Insulation: The primary means of insulation and isolation of main and vertical bus shall be by air gap. Minimal use of insulating material in addition to air gap shall be provided. Individual bus bars exposed in cabinet shall be wrapped with factory-applied, flame-retardant tape or factory-applied shrink-wrap tubbing.

    a. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

E. Circuit-Breaker Compartment:

1. Electrically Operated Draw-out Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

    a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed, and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
    b. Circuit-Breaker Positioning: Permit racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when compartment door is closed unless live parts are covered by a full dead-front shield. Permit manual withdrawal of an open circuit breaker to a position for removal from structure. When compartment door is open, status for connection devices for different positions includes the following:

        1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
        2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on stationary part of compartment. The disconnect must consist of a set of contacts extending to rear through an insulating support barrier, and of corresponding moving finger contacts on power circuit-breaker studs, which engage in only "connected" position. The assembly must provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts

with uniform pressure on each finger. Load studs must connect to bus extensions that terminate in solderless terminals in rear cable compartment.

3. Secondary Disconnect: Floating terminals mounted on stationary part of compartment that engage mating contacts at front of breaker. Disconnecting devices must be gold plated, and engagement must be maintained in "connected" and "test" positions.
4. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.
5. Place larger circuit breakers at the bottom of switchgear.
6. All space for circuit breaker shall be fully bussed and dressed to receive future breakers.
7. Complete operation of the circuit breaker and trip unit must be accessible without opening the circuit breaker door.
8. Padlocking provisions shall permit locking the circuit breaker in either the “test” or “disconnected” position.
9. Safety shutters shall be provided to cover the circuit breaker primary line and load disconnects.
10. Each circuit breaker compartment shall contain a rejection feature that allows only the insertion of an intended circuit breaker.
11. All circuit breakers of like size and ratings shall be completely interchangeable.
12. Each compartment shall contain Shutter-less Wall/Barriers that provides a physical touch-safe barrier between the busbars and operator.
13. Hinged front panels for access to breakers.

F. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:

1. Hinged front panels for access to metering, accessory, HMI and blank compartments.
2. Hinge front panel for access to Surge Protection Unit with molded case circuit breaker.
3. Remote HMI/OIT Cabinet: Provide standalone / remote vertical section to house the remote HMI/OIT system.

    a. Provide one (1) complete stand-alone control cabinet for system status, metering and remote breaker operation. Cabinet shall include an HMI/OIT panel with virtual control for each breaker. Include a verification step in “Open” and “Close” sequence to avoid nuisance operations.

G. Circuit Breakers:

1. Comply with IEEE C37.13 and UL 1066.
2. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
3. Draw-out Type: Unfused, power operated with electronic trip devices.
4. Operating Mechanism: Electrically Operated at gear or from remote Human Machine Interface / Operator Interface Terminal (HMI/ OIT).

5. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

    a. Normal Closing Speed: Independent of both control and operator.
    b. Slow Closing Speed: shall not be required to properly maintain the breaker contacts.
    c. Stored-Energy Mechanism: Electrically charged, and operator's choice of manual charging.

        1) Operating Handle: One for each circuit breaker capable of manual operation.
        2) Electric Close Button: One for each electrically operated circuit breaker.
        3) Two-step, stored-energy closing. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation.

    d. Operation counter.
    e. Provide an interlock to discharge the stored energy mechanism before the circuit breaker can be withdrawn from its compartment.
    f. Provide remote trip and close breaker from HMI / OIT.
    g. Remote Racking Capability with control box and matching receptacle connection.

6. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or multiple current transformers or sensors per phase, a release mechanism, and the following features:

    a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
    b. Temperature compensation that ensures accuracy and calibration stability from 23 to 104 deg F (minus 5 to plus 40 deg C).
    c. Field-adjustable, time-current characteristics.
    d. Equipped with self-powered, microprocessor-based trip device to sense overload and short circuit conditions. The device shall measure true RMS current. The tripping system shall consist of high accuracy (less than 1%) coil sensors on each phase, a release mechanism, Field Installable and interchangeable front mounted trip units. The trip unit shall include LCD Display type.
    e. The trip unit shall have an information system that utilizes battery backup LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip. A test pushbutton shall energize a LED to indicate the battery status.
    f. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual

indication that the internal circuitry is being monitored and is fully operational.

g. The trip unit shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.

h. Trip unit shall have selectable powered and unpowered thermal memory for enhanced circuit protection.

i. The trip unit shall include a power/relay module which shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available.

j. Trip units shall include the following field-adjustable functions:

    1) Functions: Long term, short term, and instantaneous protection function shall be providing (EIP) to allow the breaker to be applied at the withstand rating for the breaker with minus 0% tolerance so that there is not instantaneous override whatsoever.
    2) Each shall have an adjustable pick-up setting. In addition, long time and short time bands shall each have adjustable time delay. Short time function shall include a switchable I2t ramp.
    3) Trip Indication: Labeled, battery-powered LED lights shall indicate an over-current, short-circuit, or ground-fault trip condition.
    4) Current Adjustability shall be accomplished by use of dial settings keypad and rating plugs on trip units or LCD display with device plugin.
    5) Pickup Points: Minimum of 8 field adjustable Settings.
    6) The trip unit shall be equipped for remote monitoring and control. Following Modbus TCP/IP over Ethernet.
    7) Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

k. Communication Capability: Circuit-breaker-mounted Integral communication module with following functions:

    1) Metering display accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.
    2) The unit shall monitor the following data:
        a) Instantaneous value of phase, neutral and ground current
        b) Instantaneous value of line-to-line voltage
        c) Minimum and maximum current values
        d) Watts, Vars, VA, Watt-hours, Var-hours and VA hours

3) The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit's alphanumeric display panel.
4) The trip unit shall display the following power quality values: crest factor, power factor, percent total harmonic distortion, and harmonic values of all phases through the 31st harmonic.
5) Waveform Capture shall be included and saved in memory.
6) All the trip unit metering information shall be viewable at the HMI / OIT and downloadable to a memory storage device, such a USB Drive.

l. Arc Flash Reduction Function: The trip unit shall utilize a Maintenance Mode Technology for Arc Flash Reduction Maintenance System. The Technology shall be provided in a system that shall reduce the trip unit Instantaneous pickup value when activated. The device shall not compromise breaker phase protection even when enabled. Once the unit is disabled, the recalibration of trip unit phase protection shall not be required. Activation and deactivation of the Maintenance Mode Technology trip setting shall be accomplished without opening the circuit breaker door and exposing operators to energized parts. The Technology shall provide a clearing time of 0.04 seconds, adjustable with a minimum of five settings ranging from 2.5X to 10X of the sensor value.

1) The Technology shall be enabled via a switch on the trip unit. It shall also provide confirmation of protection via a Blue LED.
2) The Technology shall be provided with remote "enable/disable" control
3) The Technology shall be provided with a switchgear panel mounted enable pad-lockable selector switch and indication via Blue LED pilot light.
4) The Technology shall be wired locally with interposing relays and wired to terminal blocks to enable a remote selector switch and confirmation light to be mounted at the downstream protected distribution equipment.

7. Auxiliary Contacts:

a. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
b. Spare auxiliary switches, at least two, unless other quantity is required. Each switch must consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

8. Arc Chutes: Readily removable from associated circuit breaker when it is in "disconnected" position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
9. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

H. Power Transfer Configuration for Main – Tie – Main:

1. Automatic Transfer Control: Must have a microprocessor-based automatic transfer control scheme with auto/manual selector.
2. Factory-installed and tested controls of circuit breakers to accomplish automatic transfer controls for switchgear having two main utility power sources.

    a. Normal operation is Dual Line source: Tie “Open”, both Mains “Closed” operating on Line power.
    b. Single Line source outage: “Open” Main of lost Line and “Close” Tie to feed across the bus from single Line source. Closing of the Tie shall be time delayed coordinating with the emergency generator sequencing. Time delay shall be adjustable between 0 and 180 seconds.
    c. Dual Utility source outage: “Open” Mains, Tie “Open”, standby for Line source return.
    d. Include an “Inhibit” for the auto transfer control from the Paralleling Switchgear Master Controller to hold while Paralleling Switchgear is completing generator startup and load transfers.

3. Power for the transfer control shall be from the voltage sensing transformers.
4. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative sequence voltage protection.
5. The transfer control system shall be indicated on the HMI dashboard. The dashboard shall show the status of the system as it is operating. When timers are functioning, the dashboard shall show the timer counting down.

I. Key Interlocks: Provide interlock to prevent opening of the primary side interrupter switch when the main circuit breaker is closed.

1. In addition to the key provided for each lock, provide one additional spare key of each type.

J. Undervoltage Trip Devices: shall have adjustable time-delay and pickup voltage.
K. Indicating Lights: LED Type to indicate circuit breaker is open or closed.

2.8 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. Voltage: 277/480 V.
2. Amperage: 5000.
3. Phase: Three; 4 wire.
4. Percent of Neutral Capacity: 100.
5. Short-Circuit Interrupting Rating: 200 symmetrical kAIC.
6. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.

7. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
8. Ground: 50 percent capacity, integral with housing.
9. Enclosure: Steel, with manufacturer's standard finish.
10. Fittings and Accessories: Manufacturer's standard.
11. Mounting: Arranged flat, edgewise, or vertically without derating.

2.9 LOW-VOLTAGE INSTRUMENT AND CONTROL SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.

B. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

C. Power Distribution Equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet. Includes connection to the Remote HMI/OIT, SCADA and BMS syatems.

D. Ethernet Connectivity: Gear Supplier shall provide their standard communication network to comply with the performance of this sub-paragraph.

1. Install a multipoint, Modbus TCP communications network, by suppling manufacturer standard within the switchgear to interconnect all breaker trip units, and metering devices equipped with communications.
2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.
3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-T LAN.
4. All serial communications devices within the equipment shall be addressed at the factory and tested.
5. The supplier has option to provide Modbus TCP/IP over Ethernet direct to each breaker in lieu of serial Modbus and gateways.

E. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.

2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    i. Accumulated energy, in MWh (MJ), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Event Waveform Capture shall record the voltage and current waveforms for each event exceeding settable thresholds. stored values unaffected by power outages for up to 72 hours.
4. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements over Ethernet using Modbus TCP for connection to HMI / OIT and downloadable to USB Drive.
5. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.

F. Analog Instruments: Rectangular, 4-1/2 inch (115 mm) square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with "off" position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Locate meter and selector switch on circuit-breaker compartment door for main and feeder circuits.

G. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

H. Surge Suppression:

1. Factory installed as an integral part of low-voltage switchgear, complying with UL 1449 SPD, Type 1 , provide the following features and accessories:

    a. Integral disconnect switch.
    b. Internal thermal protection that disconnects SPD before damaging internal suppressor components.
    c. Indicator light display for protection status.
    d. Form-C contacts rated at 5 A 250 V(ac), one N.O. and one N.C., for remote monitoring of protection status. Contacts must reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
    e. Surge counter.
    f. MCOV of the SPD shall be the nominal system voltage.

g. Comply with UL 1283, RFI/Noise filter.
h. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 240 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
i. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1) Line to Neutral: 1000 V for 480Y/277 V.
2) Line to Ground: 1200 V for 480Y/277 V.
3) Line to Line: 1800 V for 480Y/277 V.
4) Neutral to Ground: 900 V for 480/277 V.

j. SCCR: Equal or exceed 200 kA.

1) Nominal Rating: 20 kA.
2) MOV's shall be large block and thermally protected

I. Control Power Supply:

1. Control power transformer supplying 120 V control circuits through secondary disconnect devices for 480V secondary distribution sections.
2. Place transformers larger than 3 kVA in separate compartments at the bottom of the vertical section, including the related primary and secondary fuses.
3. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.

4. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

J. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized in accordance with NFPA 70 for duty required.

K. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions. Provide one for each unit substation if handle is not integral with breaker.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear. Provide two total.

3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays. Provide two total.
4. Circuit-Breaker Removal Apparatus:

    a. Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments. Provide one total.
    b. Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed. Provide one for each unit substation

5. Gear Maintenance Cabinet: Identified and compartmented steel cabinet with lockable hinged doors. Sized for breaker remote racking out devices, breaker test devices, flexible cord sets and miscellaneous gear equipment.
6. Storage for Manual: Include a rack or holder, near gear for operating instructions, one-line and copy of maintenance manual.

2.10 IDENTIFICATION, WARNING LABELS AND SIGNS

A. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for OSHA 29 CFR 1910.269.

1. Warning signs must be baked enamel signs.
2. Equipment Identification Labels: Laminated acrylic or melamine plastic signs.

B. Compartment Nameplates: Engraved, metal nameplate for each compartment, mounted with corrosion-resistant screws.

C. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Color: Contrasting with factory-finish background.

2.11 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Perform design and routine tests in accordance with standards specified for components. Conduct transformer tests in accordance with IEEE C57.12.90. Conduct switchgear tests in accordance with NEMA C 37.51.
2. Perform the following factory-certified tests on each secondary unit substation:

    a. Resistance measurements of all windings on rated voltage connection and on tap extreme connections.
    b. Ratios on rated voltage connection and on tap extreme connections.
    c. Polarity and phase relation on rated voltage connection.

d. No-load loss at rated voltage on rated voltage connection.
e. Exciting current at rated voltage on rated voltage connection.
f. Impedance and load loss at rated current on rated voltage connection and on tap extreme connections.
g. Applied potential.
h. Induced potential.

3. All serial communications devices within the equipment shall be addressed at the factory and tested to verify reliable communications to the equipment's Ethernet gateway.
4. All protective devices shall tested at the factory.
5. Low-voltage switchgear assembly will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

B. Owner has ability to witness required factory tests as they are being scheduled and executed on the factory floor. Notify Owner’s Project Representative at least 30 days before starting date of tests and indicate their approximate test schedule and duration.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Provide factory certified technician(s) to complete tests, adjustments and inspections. See above, Part 1 - 1.10 Warranty and Part 1 – 1.11 Start-Up.

3.2 SYSTEM FUNCTION COMMISSIONING TESTS

A. Manufacturer's Field Service: Provide factory-authorized service technician(s) to provide startup and commissioning of Substations.

1. Services to include service technician(s) being on site as each circuit breaker is energized to test programing and functionality.
2. Test automatic transfer control scheme.
3. Provide documentation confirming results of testing.
4. Provide field programming and breaker setting adjustments required to complete field quality control, startup and commissioning.

B. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.
1. Provide test parameters documents and submit to Owner/Project Representative minimum of eight (8) weeks prior to testing for review and approval.
2. Perform approved submittal tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.

3. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
4. Verify the correct operation of sensing devices, alarms, and indicating devices.

C. Provide complete startup and commissioning test report for each Unit Substation.

3.3 FACTORY WITNESS TEST

A. The substation manufacturer shall include in the proposal a factory witness test that provides testing of the switchgear lineup, including failure recovery operations. The manufacturer shall provide the ability to simulate source loss, circuit breaker failure and undervoltage and overload events. Factory testing schedule shall be provided minimum of four weeks prior to testing for coordination of travel accommodations. The proposal shall include Owner travel expenses:

1. Include costs associated with Owner travel expense to witness factory testing. Total value attributed to travel expense shall be clearly indicated.
2. Expenses shall include roundtrip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for two Owner Representatives, with origin of Indianapolis, IN.

END OF SECTION 261116.11

SECTION 261116.11.1 - SECONDARY UNIT SUBSTATIONS WITH SWITCHGEAR SECONDARY - INSTALL

PART 1 - GENERAL

1.1 SUMMARY

A. Installation of Secondary Unit Substations with Switchgear Secondary.

B. Related Requirements:
   1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   2. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.2 DEFINITIONS

A. NETA ATS: Acceptance testing specification.

1.3 SUBMITTALS

A. Product Data: For each type of product.

   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Field Connection Wiring Diagrams: Power, signal, and control wiring.
   2. Dimensioned plans and elevations showing major components and features.

      a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.

   3. One-line diagram.
   4. List of materials.
   5. Nameplate legends.

C. Primary Fuses: Submit recommendations and size calculations.

D. Field quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Store secondary unit substation components protected from weather and so condensation does not form on or in units. Provide temporary heating in accordance with manufacturer's instructions.

D. Handle secondary unit substation components in accordance with manufacturer's instructions. Use factory-installed lifting provisions.

1.5 WARRANTY

A. Installer’s Warranty Period: Provide a warranty for one year from the date of substantial completion. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include coverage for labor, material and expense costs to correct all defects.

E. Warranty requirements specified in the Owner’s contract documents which are more stringent than those listed in this specification shall override these requirements.

PART 2 - PRODUCTS

2.1 Provide Gear Maintenance Cabinet: Identified and compartmented steel cabinet with lockable hinged doors. Sized for breaker remote racking out devices, breaker test devices, flexible cord sets and miscellaneous gear equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with applicable portions of NECA 400, NECA 410, NECA 430, and NEMA SG 11.

B. Install secondary unit substations on concrete equipment base(s). See structural sheets for equipment base details.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Install number of signs required to be readable from each accessible side, but space signs a maximum of 30 ft. apart.
2. Install arc-flash warning labels specified in Section 260573.19 "Arc-Flash Studies."

B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with maintenance materials.

3.4 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Field tests must be witnessed by Project Manager Representative.

B. General Field Testing Requirements:

1. Comply with provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at substation is tested at specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:

a. Verify equipment nameplate data complies with Contract Documents.
b. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

C. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required area clearances.
c. Verify unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to address of circuit breaker that is used to identify it in microprocessor-communication software.
e. Verify that current and voltage-transformer ratios correspond to Drawings.
f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
h. Inspect insulators for evidence of physical damage or contaminated surfaces.
i. Verify correct barrier and shutter installation and operation.
j. Exercise all active components.
k. Inspect mechanical indicating devices for correct operation.
l. Verify that filters are in place and vents are clear.
m. Inspect control power transformers as follows:

1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If temperature of bus is other than plus or minus 20 deg C, adjust resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.

c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate applied voltage, follow manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.

d. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing primary winding with system voltage.

e. Perform current-injection tests on entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in secondary circuit. Verify correct magnitude of current at each device in circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in secondary circuit. Verify correct magnitude of current at each device in circuit.

f. Verify operation of space heaters.
g. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify arresters are clean.
d. Verify that ground lead on each device is individually attached to a ground bus or ground electrode.
e. Verify that stroke counter is correctly mounted and electrically connected if applicable. Record stroke counter reading.

2. Electrical Test:

a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in table.
b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

E. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by manufacturer are available for servicing and operating breaker.
d. Verify unit is clean.
e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by manufacturer. Critical distances of operating mechanism must be in accordance with manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Perform time-travel analysis. Travel and velocity values must be in accordance with manufacturer's published data.
k. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of lowest value. Microhm or dc millivolt drop values must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of trip and close coils must comply with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer' published data.
e. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.
f. Perform power-factor or dissipation-factor tests on each pole with breaker open and each phase with breaker closed. Power-factor or dissipation-factor values must meet manufacturer's published data.
g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with contacts in "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by end of total time of voltage application during vacuum bottle integrity test, test specimen is considered to have passed test.
h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.
i. Verify operation of heaters.

F. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Verify correct connection of transformers with system requirements.

c. Verify that adequate clearances exist between primary and secondary circuit wiring.
d. Verify unit is clean.
e. Verify that required grounding and shorting connections provide contact.
f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate applied voltage, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers must not be less than values shown in NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1. Polarity results must agree with transformer markings.
c. Perform a ratio-verification test using voltage or current method in accordance with IEEE C57.13.1. Ratio errors must comply with IEEE C57.13.
d. Perform an excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1. Excitation results must match curve supplied by manufacturer or must comply with IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1. The measured burdens must match instrument transformer Accuracy Class rating.
f. Perform insulation-resistance tests on primary winding with secondary grounded. Test voltages must comply with NETA ATS, Table 100.5. The insulation-resistance value must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
g. Perform dielectric-withstand-voltage tests on primary winding with secondary grounded. Test voltages must comply with NETA ATS, Table 100.9. If no evidence of distress or insulation failure is observed by end of total time of voltage application, primary winding is considered to have passed test.
h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with test equipment manufacturer's published data.
i. Verify that current-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply test voltage for one minute in accordance with NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate applied voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages must be applied for one minute in accordance with NETA ATS, Table 100.5. Insulation-resistance values of transformers must not be less than values shown in NETA ATS, Table 100.5.
c. Perform a polarity test on each transformer to verify polarity marks or H(1)-X(1) relationship. Polarity results must agree with transformer markings.
d. Perform a turns-ratio test on all tap positions. Ratio errors must not exceed tolerances specified in IEEE C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared to instrument transformer ratings. The measured burdens must match instrument transformer Accuracy Class rating.
f. Perform a dielectric-withstand-voltage test on primary windings with secondary windings connected to ground. The dielectric voltage must comply with NETA ATS, Table 100.9. The test voltage must be applied for one minute. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, primary windings are considered to have passed test.
g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with test equipment manufacturer's published data.
h. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

G. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean front panel and remove foreign material from case.
e. Check tightness of connections.
f. Verify that frame is grounded in accordance with manufacturer's instructions.
g. Set relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Studies."
h. Download settings from relay. Print a copy of settings for report and compare settings to those specified in coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to grounded frame in accordance with manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of relay meter functions.
c. Functional Operation: Check functional operation of each element used in protection scheme as follows:

1) Timing Relay (IEEE C37.2 Device No. 2):

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Sync Check Relay (IEEE C37.2 Device No. 25):

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

3) Undervoltage Relay (IEEE C37.2 Device No. 27):

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on timing curve for inverse time relays.

4) Directional Power Relay (IEEE C37.2 Device No. 32):

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on timing curve for inverse time relays.
f) Plot operating characteristic.

5) Phase Balance Current Relay (IEEE C37.2 Device No. 46):

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

6) Negative Sequence Current Relay (IEEE C37.2 Device No. 46):

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on I-two-squared-t curve.

7) Phase Sequence or Phase Balance Voltage Relay (IEEE C37.2 Device No. 47):

a) Determine positive sequence voltage to close N.O. contact.
b) Determine positive sequence voltage to open N.C. contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close N.O. contact with sudden application of 120 percent of pickup.
e) Determine time delay to close N.C. contact upon removal of voltage when previously set to rated system voltage.

8) Instantaneous Overcurrent Relay (IEEE C37.2 Device No. 50):

a) Determine pickup.
b) Determine dropout.

9) Time Overcurrent Relay (IEEE C37.2 Device No. 51):

a) Determine minimum pickup.
b) Determine time delay at two points on time current curve.

10) Overvoltage Relay (IEEE C37.2 Device No. 59):

a) Determine overvoltage pickup.
b) Determine time delay to close contact with sudden application of 120 percent of pickup.

11) Directional Overcurrent Relay (IEEE C37.2 Device No. 67):

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine overcurrent unit pickup.
d) Determine overcurrent unit time delay at two points on time current curve.

12) Differential Protective Relay (IEEE C37.2 Device No. 87):

a) Determine operating unit pickup.
b) Determine operation of each restraint unit.
c) Determine slope.
d) Determine harmonic restraint.
e) Determine instantaneous pickup.

d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.
b) Check output contacts or SCRs, preferably by operating controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) For pilot schemes, perform a loop-back test to check receive and transmit communication circuits.
e) For pilot schemes, perform satellite synchronized end-to-end tests.
f) For pilot schemes with direct transfer trip (DTT), perform transmit and received DTT at each terminal.
g) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

H. Large Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify unit is clean.
e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
g. Perform specific inspections and mechanical tests recommended by manufacturer.
h. Verify that as-left tap connections are as specified.
i. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.

b. Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:

1) 2.0 percent for power transformers.
2) 5.0 percent for distribution transformers.

c. Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values must not be less than 1 megohm at 500 V(dc).
d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

I. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that all maintenance devices are available for servicing and operating breaker.
d. Verify unit is clean.
e. Verify that arc chutes are intact.
f. Inspect moving and stationary contacts for condition and alignment.
g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of breaker are correct.
h. Perform mechanical operator and contact alignment tests on both breaker and its operating mechanism in accordance with manufacturer's published data.
i. Verify cell fit and element alignment.
j. Verify racking mechanism operation.
k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
l. Perform adjustments for final protective-device settings in accordance with coordination study provided by end user.
m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations must be investigated.
b. Measure contact resistance across each power contact of circuit breaker. Microhm or dc millivolt drop values must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's

published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.

c. Determine long-time pickup and delay by primary current injection. Long-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times must not exceed value shown in NETA ATS, Table 100.7.

d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.

e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.

f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In absence of manufacturer's published data, comply with NETA ATS, Table 100.8.

g. Test functions of trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.

h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must conform to manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.

i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

j. Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in accordance with manufacturer's published data.

k. Verify operation of charging mechanism. The charging mechanism must operate in accordance with manufacturer's published data.

J. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.

c. Verify unit is clean.

d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
b. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
c. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results must confirm integrity of secondary circuits of current and voltage transformers.

K. Nonconforming Work:

1. Equipment will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

L. Prepare test and inspection reports.

M. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.6 ADJUSTING

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

a. Adjust transformer taps.
b. Rebalance loads.
c. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report:

a. Prepare a written report covering monitoring performed and corrective action taken.

b. For each relay and adjustable circuit breaker, tag device with adjusting technician's initials and date of adjustment. Record settings and file with test records specified in "Field Quality Control" Article.

B. Infrared Inspection and Adjusting: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of electrical power connections of unit substation.
2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
3. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1.8 deg F at 104 deg F.
4. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists the following results:

a. Description of equipment to be tested.
b. Discrepancies.
c. Temperature difference between area of concern and reference area.
d. Probable cause of temperature difference.
e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
f. Identify load conditions at time of inspection.
g. Provide photographs and thermograms of deficient area.

5. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.7 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

END OF SECTION 261116.11.1

SECTION 261116.12 - SECONDARY UNIT SUBSTATIONS WITH MV SWITCHGEAR SECONDARY – PURCHASE.

PART 1 - GENERAL

1.1 SUMMARY

A. Unit Substations to be purchased:

1. USS-CH-01 – 7500KVA, 80 deg C AA / 133% FA rated, 13,200V delta to 4160/2300V wye, Cast Coil, Main-Tie-Main distribution switchgear. Fused 15KV duplex interrupter primary switch.
2. USS-CH-02 – 7500KVA, 80 deg C AA / 133% FA rated, 13,200V delta to 4160/2300V wye, Cast Coil, Main-Tie-Main distribution switchgear. Fused 15KV duplex interrupter primary switch.

B. Section Includes:

1. Manufactured units.
2. Medium-voltage metal-enclosed switchgear section.
3. Medium-voltage instruments section.
4. Dry-type transformer section.
5. Secondary MV metal-clad switchgear sections.
6. Low-voltage instrument section.
7. Includes HMI Dashboard as specified in section 262300.01.

C. Drawings: EP-503, EP-701, EP-706 and EP-707.

1.2 DEFINITIONS

A. BIL: Basic Insulation Level.

B. L.A.: Lightning Arrester.

C. MVA: Megavolt Ampere.

D. NETA ATS: Acceptance testing specification.

E. PCB: Polychlorinated biphenyl.

F. RTD: Resistance temperature detector (IEEE C37.2 Device No. 26).

G. SCR: Silicon Controlled Rectifier.

H. SPD: Surge Protective Device.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

a. Differentiate between manufacturer-installed and field-installed wiring.
b. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

2. Dimensioned plans and elevations showing major components and features.

a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
b. Identify center of gravity and locate and describe mounting and anchorage provisions.

3. One-line diagram.
4. List of materials.
5. Nameplate legends.
6. The material, size and number of bus bars, and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
7. Short-time and short-circuit current ratings of secondary unit substations and components.
8. Enclosed bus duct details.
9. Accessory information for items such as circuit breaker test set, breaker remote racking assembly, breaker lifting cart, yoke and spare equipment storage cabinet.
10. Type and Ratings of individual protective devices.
11. CT, PT and LA (Lightning Arrestor) sizes.
12. RC Snubber sizing and information.
13. Mimic-bus diagram.
14. Provide dimensioned drawings and details for the HMI/OIT standalone remote cabinet.
15. Provide spreadsheet table form list identifying all the metering and status points for interrupter switches, transformers, gear devices and breakers. In table include columns for communication method and connection to locations (gear internal, remote HMI/OIT, SCADA and BMS).

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

E. Field quality-control reports.

F. Product Certificates: For secondary unit substations, signed by product manufacturer.

G. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

H. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

I. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

J. Factory test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1. In addition to "Operation and Maintenance Data," include the following:

   a. Lists of spare parts and replacement components recommended for storage at Project site.
   b. Detailed instructions covering operation under both normal and abnormal conditions.
   c. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.
   d. Spreadsheet table list with addressing for each metering and status point.

2. Software and Firmware Operational Documentation: Provide PDF files on a USB storage device.

   a. Software operating and upgrade manuals.
   b. Program Software Backup, complete with data files.
   c. Device address list.
   d. Printout/Screen Shots of software application and graphic screens.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Six of each type and rating of fuse and fusible device used, except for medium-voltage fuses. Include spares for the following:

a. Primary disconnect fuses.
b. Potential transformer fuses.
c. Control power fuses.
d. Fuses for secondary fusible devices.

2. Spare Indicating Lights: Six of each type installed.
3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
4. Primary Switch Contact Lubricant: One container(s).

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Can be one or combination of both.

1. Member company of NETA or NRTL.

a. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

2. Manufacturer certified field service technician.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with install contractor to deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate with install contractor for delivery of secondary unit substations to allow movement into designated space.

C. Coordinate with install contractor for offloading requirements at destination.

D. Provide manufacturer's temporary heating requirement and written instructions to installing contractor.

E. Provide manufacturer's written instructions to handle secondary unit substation components. Provide factory-installed lifting provisions.

F. Provide transportation shock recorders and tilt indicators with each shipping split. Provide written tolerance requirements for each indicator type.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding 104 deg F (40 deg C).

1.9 WARRANTY

A. Manufacturer's Warranty Period: Manufacturer's maintenance and service organization shall provide a warranty of five (5) years from date of startup commissioning. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include required system hardware, software and programming updates.

E. Warranty shall include coverage for labor, material and expense costs to correct all defects.

F. Warranty requirements specified in the Owner's contract documents which are more stringent than those listed in this specification shall override these requirements.

G. Original equipment repair parts shall be available for a minimum of 10 years.

1.10 START-UP

A. Provide manufacturer certified field service technician(s) required for a complete installation. To include field programming adjustments, breaker/protection relay setting adjustments, start up, field quality control and commissioning of equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ABB (G.E.)

B. Eaton

C. Schneider Electric, Square D

D. Siemens

2.2 SYSTEM DESCRIPTION

A. Description: Medium-voltage, primary incoming section; transformer section; and medium-voltage metal-clad secondary switchgear sections; and including coordinated circuit breaker/protection relaying, fusible switches, and metering components.

1. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Comply with IEEE C37.04
3. Comply with IEEE C37.20.2
4. Comply with NEMA SG 4

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The secondary unit substations shall withstand the effects of earthquake motions determined according to ASCE/SEI 7**.**

1. The term "withstand" means "the secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified and the secondary unit substation will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

2.4 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Separate secondary distribution equipment connected with busway.

B. Connections between primary device and transformer must be bus, and between transformer and secondary must be flexible bus braid unless noted otherwise.

C. Indoor Enclosure: Steel.

D. Unit Substation Enclosures Finish:

1. Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 MEDIUM-VOLTAGE METAL-ENCLOSED SWITCHGEAR SECTION

A. Metal-enclosed, air-interrupter switchgear, with fuses, complying with IEEE C37.20.3.

B. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60 Hz, solidly grounded-neutral system.

1. System Voltage: 13.2kV nominal; 15kV maximum.
2. Design Level of Available-Source Fault Current: 25kA Symmetrical.
3. Main-Bus Rating: 600A, continuous.

C. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.

1. Rating: 600A continuous duty and load break.
2. Two-Time Duty-Cycle Fault Closing: 40 000A, asymmetrical.
3. Switch Action: No external arc and no significant quantities of ionized gas released into enclosure.
4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
6. Protective Shields: Cover live components and terminals.

    a. Fuse Mounts: Single-frame mounted and de-energized when switch is open.

7. Mechanical Interlock: Prevent opening of switch compartment door unless switchblades are open, and prevent closing switch if door is open. Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
8. Window: Permits viewing switchblade positions when door is closed.
9. Rear cabinet door shall be hinged, provided with three-point latch mechanism operated by a 180-degree handle with padlock able hasp.
10. IR window ports aligned with cable terminations on rear cable compartment door.
11. Ground bus shall include a grounding ball stud, with removable insulated cover.

D. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.

1. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
2. Indicator integral with each fuse to show when it has blown.
3. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

E. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

F. R.C. Snubber Circuit: Comply with IEC 60871-1, ANSI / IEEE Standard 18 NEMA CP-1.

1. R.C. Snubber Circuit may be installed in the Switch cabinet or as part of the Transformer.

2.6 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.51, and dry-type, two-winding, secondary unit substation transformer.

B. Style:

1. Indoor, ventilated, cast coil/encapsulated coil, with primary and secondary copper windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 104 deg F (40 deg C).

C. Cooling System:

1. Class AFA, forced-air cooling, complying with IEEE C57.12.01.

a. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.

1) High-Temperature Alarm: Part of controls at transformer with local audible and visual alarm and contacts for remote alarm.

b. Include cooling fans.
c. Provide power for the controls from a separate control power transformer in the transformer section or from control power in the distribution section.
d. Controls Communication: Unit shall be equipped for remote monitoring. Using Modbus TCP/IP over Ethernet.

D. Insulation Materials: IEEE C57.12.01, rated 220 deg C.

1. Insulation Temperature Rise: 80 deg C, maximum rise above 104 deg F (40 deg C).

E. BIL: 95 kV.

F. Full-Capacity Voltage Taps:

1. Four nominal 2.5 percent taps, two above and two below rated primary voltage.

G. R.C. Snubber Circuit: Comply with IEC 60871-1, ANSI / IEEE Standard 18 NEMA CP-1.

1. R.C. Snubber Circuit may be installed in the Switch cabinet or as part of the Transformer.

H. Transformer enclosure side panels shall be hinged with captive bolts to secure the panels to the enclosure frame.

I. IR window ports aligned with cable terminations on the side panels.

2.7 SECONDARY MV METAL-CLAD SWITCHGEAR

A. Deadfront, metal-clad, draw-out, switchgear assembly of vertical sections, with vacuum circuit breakers. Provide additional vertical sections to house accessories related to the switchgear functions.

1. Front and rear access switchgear.
2. Front and rear vertical section covers with hinges. The front and rear cover must be a flanged door with latching hardware. The latching hardware shall be lockable by a padlock suitable for lockout protection.
3. Infrared Window: Each breaker rear cable connection stabs shall contain round window ports. The ports shall be 4”. The window ports quantity and locations for each breaker must be positioned to provide optimal viewing with external infrared camera.

B. Bus: Tin-plated copper.

1. Phase Bus: 1200A, epoxy insulated bus. All bus joints shall be plated, bolted and insulated with easily installed boots.
2. Ground Bus: Sized to carry the rated short-time withstand current, extended full length of the switchgear assembly, and connected to the metal enclosures of each vertical section.
3. Grounding Stud Ball: Each rear cabinet shall include a grounding stud ball connection for safety grounding. Provide hot-stick removable insulated ball cover.

C. Circuit Breaker Compartments: Include a racking mechanism, circuit breaker operated automatic shutters covering the high-voltage bus connections, safety interlocks, and an electrical racking motor and accessories for remote racking of the circuit breaker.

1. Draw out Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.

2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts on the breaker. Disconnecting devices shall be silver plated, and engagement shall be maintained in the "connected" and "test" positions.
4. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.
5. All space for circuit breaker shall be fully bussed and dressed to receive future breakers.
6. Complete operation of the circuit breaker and trip unit must be accessible without opening the circuit breaker door.
7. Padlocking provisions shall permit locking the circuit breaker in either the “test” or “disconnected” position.
8. Safety shutters shall be provided to cover the circuit breaker primary line and load disconnects.
9. Each circuit breaker compartment shall contain a rejection feature that allows only the insertion of an intended circuit breaker.
10. All circuit breakers of like size and ratings shall be completely interchangeable.
11. Each compartment shall contain Shutter-less Wall/Barriers that provides a physical touch-safe barrier between the busbars and operator.

D. Auxiliary Vertical Sections and Compartments:

1. Match and align with basic switchgear assembly. Hinged front panels for access to compartment.

2. Owner's Metering: A vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.
3. Remote HMI/OIT Cabinet: Provide standalone / remote vertical section to house the remote HMI/OIT system.

    a. Provide one (1) complete stand-alone control cabinet for system status, metering and remote breaker operation. Cabinet shall include an HMI/OIT 24” panel with virtual control for each breaker. Include a verification step in “Open” and “Close” sequence to avoid nuisance operations.

E. Circuit Breakers: Horizontally mounted, draw-out, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

F. Capacities and Characteristics:

1. Comply with IEEE ANSI C37.06.
2. Switchgear Assembly:

a. System Voltage 2300/4160V, three-phase.
b. Rated Maximum Design Voltage and BIL (Dielectric Test): 5 kV, 60 kV.
c. Rated Continuous Current: 1200 A.
d. Rated Short-Circuit Current and Short-Time Current: 63 kA RMS.
e. Power Frequency Withstand: 19KV.
f. Momentary Current Ratings: Equal to the circuit breaker close and latch rating.

3. Circuit Breakers: Horizontally mounted, draw-out, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

a. Electrically Operated: 120V(ac) close and ac capacitor trip. Powered from a fused control power transformer integral to the switchgear.
b. Same capacities and characteristics as the switchgear assembly, and as follows:

1) Rated Continuous Current and Load Switching Current:
a) Main and Tie: 1200 A.
b) Feeder: 1200A.
2) Rated Closing and Latching Current: 163 kA, peak.
3) Rated Interrupting Time: 50 ms.

2.8 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: Segmented bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. C37.23
2. Voltage: 4160 V.
3. Amperage: 1200.
4. Phase: Three; 3wire.
5. Short-Circuit Interrupting Rating: 63 symmetrical kAIC.
6. Temperature Rise: 65 deg C above 40 deg C ambient maximum for continuous rated current.
7. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
8. Ground: 50 percent capacity, integral with housing.
9. Enclosure: Steel or aluminum, with manufacturer's standard finish.
10. Fittings and Accessories: Manufacturer's standard.

11. Mounting: Arranged flat, edgewise, or vertically without derating.

2.9 SURGE ARRESTERS

A. Comply with IEEE ANSI C62.11, distribution class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

2.10 INSTRUMENTS

A. Instrument Transformers: Comply with IEEE ANSI C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

B. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

C. Control Power Supply:

1. Control power transformer(s) supplying 24V and 120 V control circuits through control power transformers.
2. Place transformers larger than 3 kVA in separate compartments at the bottom of the vertical section, including the related primary and secondary fuses.
3. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

    a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.

4. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

D. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized in accordance with NFPA 70 for duty required.

E. Power Distribution Equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet.

F. Ethernet Connectivity: Gear Supplier shall provide their standard communication network to comply with the performance of this sub-paragraph.

1. Install a multipoint, Modbus TCP communications network, by suppling manufacturer standard within the switchgear to interconnect all breaker trip units, and metering devices equipped with communications.
2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.
3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-T LAN.
4. All serial communications devices within the equipment shall be addressed at the factory and tested.
5. The supplier has option to provide Modbus TCP/IP over Ethernet direct to each breaker in lieu of serial Modbus and gateways.

G. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Three-Phase Apparent Power: Plus or minus 2 percent.
    g. Power Factor: Plus or minus 2 percent.
    h. Frequency: Plus or minus 0.5 percent.
    i. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    j. Accumulated energy, in megawatt-hours (megajoules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Event Waveform Capture shall record the voltage and current waveforms for each event exceeding settable thresholds. stored values unaffected by power outages for up to 72 hours.
4. Communications module suitable for remote monitoring of meter quantities and functions. Information to be communicated in Modbus TCP over Ethernet. Connections to HMI / OIT, SCADA, BMS and downloadable to USB Drive.
5. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
6. Provide metering for each circuit breaker installed.

H. Analog Instruments: Rectangular, 4-1/2 inch (115 mm) square, 1 percent accuracy, semiflush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase voltages.
3. Locate meter and selector switch on circuit-breaker compartment door for Main and Tie Breakers only.

2.11 PROTECTIVE RELAYS

A. Multifunctional, solid-state microprocessor-based relay systems, complying with IEEE ANSI C37.90.

B. Relay Mounting:

1. Each relay must be mounted in a drawout case with a two-stage quick-release operation.
2. Removal of the relay from the case must disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.
3. When the relay is inserted into the case, control power connections must be made before the trip circuits are activated.
4. Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.
5. Provide required CT and PT and wiring to each digital protective relay.
6. Provide fiber optic arc flash detection sensors, wiring and connections as required for arc flash detection coverage of each corresponding side of the switchgear. Set for flash and current rate of rise.
7. Provide maintenance setting switch on protective relay to reduce arc flash hazard when the switch is in the maintenance mode position.
8. Manufacturer must provide initial protection relay settings to complete factory testing.
9. The manufacturer field technician onsite must complete relay setting adjustments required to meet the field quality control startup and commissioning.

C. Each relay system must include a communications module to transmit data.

1. Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
2. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

D. Overcurrent and Ground-Fault Protective Relays:

1. IEEE ANSI C37.2 and ANSI device functions as specified for each type of load. The basis of design manufacturer is SEL.
2. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.

3. Primary Current-Transformer Ratings: Programmable from 5 to 5000 A.
4. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
5. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and must be deactivated after approximately eight cycles.
6. Contacts:

    a. Two Form-A contacts.
    b. Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

        1) One contact assigned function 51 phase and function 51 ground, and the other contact assigned function 50 phase and function 50 ground.
        2) One contact assigned function 51/50 phase, and the other contact assigned function 51/50 ground.

7. Alphanumeric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current-causing trip.
    e. Phase or ground indication.
    f. Peak current demand for each phase and ground since last reset.
    g. Current-transformer primary rating.
    h. Programmed phase and ground set points.

8. Relay alarm and trip contacts must not change state if power is lost or an undervoltage occurs. These contacts must only cause a trip on detection of an overcurrent or fault condition based on programmed settings. A "protection off" alarm must be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this alarm relay must be de-energized, providing a fail-safe protection off alarm.

E. Switchgear shall include following type, rating and protection relay: SEL Relays identified as Base-Line.

1. Main Circuit Breaker: SEL 751A - ANSI 25, 27, 47, 50/51P, 50/51N, 50/51G, 50, 62, 86, and 87B.
2. Feeder Circuit Breaker: SEL 751A - ANSI 50/51P, 50/51G, 62, and 86.
3. Tie Circuit Breaker: SEL 751A - ANSI 50/51P, 50/51G, 62, and 86.

F. Power Transfer Configuration for Main – Tie – Main:

1. Automatic Transfer Control: Must have a microprocessor-based automatic transfer control scheme with auto/manual selector.
2. Factory-installed and tested controls of circuit breakers to accomplish automatic transfer controls for switchgear having two main utility power sources.

    a. Normal operation is Dual Line source: Tie “Open”, both Mains “Closed” operating on Line power.
    b. Single Line source outage: “Open” Main of lost Line and “Close” Tie to feed across the bus from single Line source. Closing of the Tie shall be time delayed coordinating with the emergency generator sequencing. Time delay shall be adjustable between 0 and 180 seconds.
    c. Dual Utility source outage: “Open” Mains, Tie “Open”, standby for Line source return.
    d. Include an “Inhibit” for the auto transfer control from the Paralleling Switchgear Master Controller to hold while Paralleling Switchgear is completing generator startup and load transfers.

3. Power for the transfer control shall be from the voltage sensing transformers.
4. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative sequence voltage protection.
5. The transfer control system shall be indicated on the HMI dashboard. The dashboard shall show the status of the system as it is operating. When timers are functioning, the dashboard shall show the timer counting down.

G. Arc Flash protection shall be provided by the protection relay or by the manufacturer recommended arc flash reduction method based on the following.

    a. Arc Flash Reduction Function: The trip unit shall utilize Maintenance Mode Technology (Arc Flash Reduction Maintenance System). The Technology shall be provided in a system that shall reduce the trip unit Instantaneous pickup value when activated. The device shall not compromise breaker phase protection even when enabled. Once the unit is disabled, the recalibration of trip unit phase protection shall not be required. Activation and deactivation of the Maintenance Mode Technology trip setting shall be accomplished without opening the circuit breaker door and exposing operators to energized parts. The Technology shall provide a clearing time of 0.04 seconds, adjustable with a minimum of five settings ranging from 2.5X to 10X of the sensor value.

        1) The Technology shall be enabled via a switch on the trip unit. It shall also provide confirmation of protection via a Blue LED.
        2) The Technology shall be provided with remote “enable/disable” control
        3) The Technology shall be provided with a switchgear panel mounted enable pad lockable selector switch and indication via Blue LED pilot light.
        4) The Technology shall be wired locally with interposing relays and wired to terminal blocks to enable a remote selector switch and

confirmation light to be mounted at the downstream protected distribution equipment.

H. Indicating Lights: To indicate circuit breaker is open or closed.

I. Key Interlocks: Provide interlock to prevent opening of the primary side interrupter switch when the main circuit breaker is closed.

1. In addition to the key provided for each lock, provide one additional spare key of each type.

J. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions. Provide one for each unit substation.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear. Provide two total.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays. Provide two total.
4. Circuit-Breaker Removal Apparatus:

a. Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments. Provide one total.
b. Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed. Provide one for each unit substation

5. Gear Maintenance Cabinet: Identified and compartmented steel cabinet with lockable hinged doors. Sized for breaker remote racking out devices, breaker test devices, flexible cord sets and miscellaneous gear equipment.
6. Storage for Manual: Include a rack or holder, near gear for operating instructions, one-line and copy of maintenance manual.

2.12 IDENTIFICATION, WARNING LABELS AND SIGNS

A. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for OSHA 29 CFR 1910.269.

1. Warning signs must be baked enamel signs.
2. Equipment Identification Labels: Laminated acrylic or melamine plastic signs.

B. Compartment Nameplates: Engraved, metal nameplate for each compartment, mounted with corrosion-resistant screws.

C. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Color: Contrasting with factory-finish background.

2.13 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Perform design and routine tests in accordance with standards specified for components. Conduct transformer tests in accordance with IEEE C57.12.90.
2. Perform the following factory-certified tests on each secondary unit substation:

    a. Resistance measurements of all windings on rated voltage connection and on tap extreme connections.
    b. Ratios on rated voltage connection and on tap extreme connections.
    c. Polarity and phase relation on rated voltage connection.
    d. No-load loss at rated voltage on rated voltage connection.
    e. Exciting current at rated voltage on rated voltage connection.
    f. Impedance and load loss at rated current on rated voltage connection and on tap extreme connections.
    g. Applied potential.
    h. Induced potential.

3. Perform production tests on each circuit breaker housing for this Project, complying with IEEE ANSI C37.09.

    a. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
    b. Conduct an alignment test with master circuit breaker to verify interfaces.
    c. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
    d. Perform the control wiring dielectric test at 1500 V for one minute.
    e. Perform the dielectric test on primary and secondary circuits.

4. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE ANSI C37.09.

    a. Perform mechanical operation tests to ensure proper functioning of the switch.
    b. Conduct an alignment test with master cell to verify interfaces and interchangeability.
    c. Verify the contact gap. Perform terminal-to-terminal resistance test.
    d. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the

intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.

e. Perform the control wiring dielectric test at 1500 V for one minute.
f. Set the contact gap.

5. All serial communications devices within the equipment shall be addressed at the factory and tested to verify reliable communications to the equipment's Ethernet gateway.
6. All protective devices shall tested at the factory.
7. Low-voltage switchgear assembly will be considered defective if it does not pass tests and inspections.
8. Prepare test and inspection reports.

B. Owner has ability to witness required factory tests as they are being scheduled and executed on the factory floor. Notify Owner’s Project Representative at least 30 days before starting date of tests and indicate their approximate test schedule and duration.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Provide factory certified technician(s) to complete tests, adjustments and inspections. See above, Part 1 - 1.10 Warranty and Part 1 – 1.11 Start-Up.

3.2 SYSTEM FUNCTION COMMISSIONING TESTS

A. Manufacturer's Field Service: Provide factory-authorized service technician(s) to provide startup and commissioning of Substations.

1. Services to include service technician(s) being on site as each circuit breaker is energized to test programing and functionality.
2. Test automatic transfer control scheme.
3. Provide documentation confirming results of testing.
4. Provide field programming and breaker/protection relay setting adjustments required to complete field quality control, startup and commissioning.

B. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Provide test parameters documents and submit to Owner/Project Representative minimum of eight (8) weeks prior to testing for review and approval.
2. Perform approved submittal tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
3. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.

4. Verify the correct operation of sensing devices, alarms, and indicating devices.

C. Provide complete startup and commissioning test report for each Unit Substation.

3.3 FACTORY WITNESS TEST

A. The substation manufacturer shall include in the proposal a factory witness test that provides testing of the switchgear lineup, including failure recovery operations. The manufacturer shall provide the ability to simulate source loss, circuit breaker failure and undervoltage and overload events. Factory testing schedule shall be provided minimum of four weeks prior to testing for coordination of travel accommodations. The proposal shall include Owner travel expenses:

1. Include costs associated with Owner travel expense to witness factory testing. Total value attributed to travel expense shall be clearly indicated.
2. Expenses shall include roundtrip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for two Owner Representatives, with origin of Indianapolis, IN.

END OF SECTION 261116.12

SECTION 261116.12.1 - SECONDARY UNIT SUBSTATIONS WITH MV SWITCHGEAR SECONDARY - INSTALL

PART 1 - GENERAL

1.1 SUMMARY

A. Installation of Secondary Unit Substations with MV Switchgear Secondary.

B. Related Requirements:
1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
2. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.2 DEFINITIONS

A. NETA ATS: Acceptance testing specification.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Field Connection Wiring Diagrams: Power, signal, and control wiring.
2. Dimensioned plans and elevations showing major components and features.

a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.

3. One-line diagram.
4. List of materials.
5. Nameplate legends.

C. Primary Fuses: Submit recommendations and size calculations.

D. Field quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Store secondary unit substation components protected from weather and so condensation does not form on or in units. Provide temporary heating in accordance with manufacturer's instructions.

D. Handle secondary unit substation components in accordance with manufacturer's instructions. Use factory-installed lifting provisions.

1.5 WARRANTY

A. Installer’s Warranty Period: Provide a warranty for one year from the date of substantial completion. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include coverage for labor, material and expense costs to correct all defects.

E. Warranty requirements specified in the Owner’s contract documents which are more stringent than those listed in this specification shall override these requirements.

PART 2 - PRODUCTS

2.1 Provide Gear Maintenance Cabinet: Identified and compartmented steel cabinet with lockable hinged doors. Sized for breaker remote racking out devices, breaker test devices, flexible cord sets and miscellaneous gear equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with applicable portions of NECA 400, NECA 410, NECA 430, and NEMA SG 11.

B. Install secondary unit substations on concrete equipment base(s) as specified in Section 260529 "Hangers and Supports for Electrical Systems."

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Install number of signs required to be readable from each accessible side, but space signs a maximum of 30 ft. apart.
2. Install arc-flash warning labels specified in Section 260573.19 "Arc-Flash Studies."

B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with maintenance materials.

3.4 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Field tests must be witnessed by Project Manager Representative.

B. General Field Testing Requirements:

1. Comply with provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at substation is tested at specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:

a. Verify equipment nameplate data complies with Contract Documents.
b. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

C. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required area clearances.
c. Verify unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to address of circuit breaker that is used to identify it in microprocessor-communication software.
e. Verify that current and voltage-transformer ratios correspond to Drawings.
f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
h. Inspect insulators for evidence of physical damage or contaminated surfaces.
i. Verify correct barrier and shutter installation and operation.
j. Exercise all active components.
k. Inspect mechanical indicating devices for correct operation.
l. Verify that filters are in place and vents are clear.
m. Inspect control power transformers as follows:

1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If temperature of bus is other than plus or minus 20 deg C, adjust resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.

c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate applied voltage, follow manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.

d. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing primary winding with system voltage.

e. Perform current-injection tests on entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in secondary circuit. Verify correct magnitude of current at each device in circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in secondary circuit. Verify correct magnitude of current at each device in circuit.

f. Verify operation of space heaters.
g. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify arresters are clean.
d. Verify that ground lead on each device is individually attached to a ground bus or ground electrode.
e. Verify that stroke counter is correctly mounted and electrically connected if applicable. Record stroke counter reading.

2. Electrical Test:

a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in table.
b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

E. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by manufacturer are available for servicing and operating breaker.
d. Verify unit is clean.
e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by manufacturer. Critical distances of operating mechanism must be in accordance with manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Perform time-travel analysis. Travel and velocity values must be in accordance with manufacturer's published data.
k. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of lowest value. Microhm or dc millivolt drop values must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of trip and close coils must comply with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer' published data.
e. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.
f. Perform power-factor or dissipation-factor tests on each pole with breaker open and each phase with breaker closed. Power-factor or dissipation-factor values must meet manufacturer's published data.
g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with contacts in "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by end of total time of voltage application during vacuum bottle integrity test, test specimen is considered to have passed test.
h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, test specimen is considered to have passed test.
i. Verify operation of heaters.

F. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Verify correct connection of transformers with system requirements.

c. Verify that adequate clearances exist between primary and secondary circuit wiring.
d. Verify unit is clean.
e. Verify that required grounding and shorting connections provide contact.
f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate applied voltage, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers must not be less than values shown in NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1. Polarity results must agree with transformer markings.
c. Perform a ratio-verification test using voltage or current method in accordance with IEEE C57.13.1. Ratio errors must comply with IEEE C57.13.
d. Perform an excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1. Excitation results must match curve supplied by manufacturer or must comply with IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1. The measured burdens must match instrument transformer Accuracy Class rating.
f. Perform insulation-resistance tests on primary winding with secondary grounded. Test voltages must comply with NETA ATS, Table 100.5. The insulation-resistance value must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
g. Perform dielectric-withstand-voltage tests on primary winding with secondary grounded. Test voltages must comply with NETA ATS, Table 100.9. If no evidence of distress or insulation failure is observed by end of total time of voltage application, primary winding is considered to have passed test.
h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with test equipment manufacturer's published data.
i. Verify that current-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply test voltage for one minute in accordance with NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate applied voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages must be applied for one minute in accordance with NETA ATS, Table 100.5. Insulation-resistance values of transformers must not be less than values shown in NETA ATS, Table 100.5.
c. Perform a polarity test on each transformer to verify polarity marks or H(1)-X(1) relationship. Polarity results must agree with transformer markings.
d. Perform a turns-ratio test on all tap positions. Ratio errors must not exceed tolerances specified in IEEE C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared to instrument transformer ratings. The measured burdens must match instrument transformer Accuracy Class rating.
f. Perform a dielectric-withstand-voltage test on primary windings with secondary windings connected to ground. The dielectric voltage must comply with NETA ATS, Table 100.9. The test voltage must be applied for one minute. If no evidence of distress or insulation failure is observed by end of total time of voltage application during dielectric-withstand-voltage test, primary windings are considered to have passed test.
g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with test equipment manufacturer's published data.
h. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE C57.13.3.

G. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean front panel and remove foreign material from case.
e. Check tightness of connections.
f. Verify that frame is grounded in accordance with manufacturer's instructions.
g. Set relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Studies."
h. Download settings from relay. Print a copy of settings for report and compare settings to those specified in coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to grounded frame in accordance with manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of relay meter functions.
c. Functional Operation: Check functional operation of each element used in protection scheme as follows:

1) Timing Relay (IEEE C37.2 Device No. 2):

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Sync Check Relay (IEEE C37.2 Device No. 25):

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

3) Undervoltage Relay (IEEE C37.2 Device No. 27):

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on timing curve for inverse time relays.

4) Directional Power Relay (IEEE C37.2 Device No. 32):

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on timing curve for inverse time relays.
f) Plot operating characteristic.

5) Phase Balance Current Relay (IEEE C37.2 Device No. 46):

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

6) Negative Sequence Current Relay (IEEE C37.2 Device No. 46):

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on I-two-squared-t curve.

7) Phase Sequence or Phase Balance Voltage Relay (IEEE C37.2 Device No. 47):

a) Determine positive sequence voltage to close N.O. contact.
b) Determine positive sequence voltage to open N.C. contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close N.O. contact with sudden application of 120 percent of pickup.
e) Determine time delay to close N.C. contact upon removal of voltage when previously set to rated system voltage.

8) Instantaneous Overcurrent Relay (IEEE C37.2 Device No. 50):

a) Determine pickup.
b) Determine dropout.

9) Time Overcurrent Relay (IEEE C37.2 Device No. 51):

a) Determine minimum pickup.
b) Determine time delay at two points on time current curve.

10) Overvoltage Relay (IEEE C37.2 Device No. 59):

a) Determine overvoltage pickup.
b) Determine time delay to close contact with sudden application of 120 percent of pickup.

11) Directional Overcurrent Relay (IEEE C37.2 Device No. 67):

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine overcurrent unit pickup.
d) Determine overcurrent unit time delay at two points on time current curve.

12) Differential Protective Relay (IEEE C37.2 Device No. 87):

a) Determine operating unit pickup.
b) Determine operation of each restraint unit.
c) Determine slope.
d) Determine harmonic restraint.
e) Determine instantaneous pickup.

d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.
b) Check output contacts or SCRs, preferably by operating controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) For pilot schemes, perform a loop-back test to check receive and transmit communication circuits.
e) For pilot schemes, perform satellite synchronized end-to-end tests.
f) For pilot schemes with direct transfer trip (DTT), perform transmit and received DTT at each terminal.
g) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

H. Large Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify unit is clean.
e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
g. Perform specific inspections and mechanical tests recommended by manufacturer.
h. Verify that as-left tap connections are as specified.
i. Verify presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; value of index must not be less than 1.0.

b. Perform power-factor or dissipation-factor tests on windings in accordance with test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:

1) 2.0 percent for power transformers.
2) 5.0 percent for distribution transformers.

c. Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values must not be less than 1 megohm at 500 V(dc).
d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

I. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that all maintenance devices are available for servicing and operating breaker.
d. Verify unit is clean.
e. Verify that arc chutes are intact.
f. Inspect moving and stationary contacts for condition and alignment.
g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of breaker are correct.
h. Perform mechanical operator and contact alignment tests on both breaker and its operating mechanism in accordance with manufacturer's published data.
i. Verify cell fit and element alignment.
j. Verify racking mechanism operation.
k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
l. Perform adjustments for final protective-device settings in accordance with coordination study provided by end user.
m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations must be investigated.
b. Measure contact resistance across each power contact of circuit breaker. Microhm or dc millivolt drop values must not exceed high levels of normal range as indicated in manufacturer's published data. If manufacturer's

published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.

c. Determine long-time pickup and delay by primary current injection. Long-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times must not exceed value shown in NETA ATS, Table 100.7.

d. Determine short-time pickup and delay by primary current injection. Short-time pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.

e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values must be as specified, and trip characteristic must not exceed manufacturer's published time-current tolerance band.

f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values must be as specified and within manufacturer's published tolerances. In absence of manufacturer's published data, comply with NETA ATS, Table 100.8.

g. Test functions of trip unit by means of secondary injection. Pickup values and trip characteristic must be as specified and within manufacturer's published tolerances.

h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must conform to manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.20.

i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

j. Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features must operate in accordance with manufacturer's published data.

k. Verify operation of charging mechanism. The charging mechanism must operate in accordance with manufacturer's published data.

J. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.

c. Verify unit is clean.

d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
b. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
c. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results must confirm integrity of secondary circuits of current and voltage transformers.

K. Nonconforming Work:

1. Equipment will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

L. Prepare test and inspection reports.

M. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.6 ADJUSTING

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

a. Adjust transformer taps.
b. Rebalance loads.
c. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report:

a. Prepare a written report covering monitoring performed and corrective action taken.

b. For each relay and adjustable circuit breaker, tag device with adjusting technician's initials and date of adjustment. Record settings and file with test records specified in "Field Quality Control" Article.

B. Infrared Inspection and Adjusting: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of electrical power connections of unit substation.
2. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
3. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1.8 deg F at 104 deg F.
4. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists the following results:

a. Description of equipment to be tested.
b. Discrepancies.
c. Temperature difference between area of concern and reference area.
d. Probable cause of temperature difference.
e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
f. Identify load conditions at time of inspection.
g. Provide photographs and thermograms of deficient area.

5. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.7 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

END OF SECTION 261116.12.1

SECTION 261326 - MEDIUM-VOLTAGE METAL-CLAD SWITCHGEAR - Purchase

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Switchgear enclosure.
2. Switchgear construction.
3. Surge arresters.
4. Instruments.
5. Protective relays.
6. Control power supply.
7. Battery system control power supply.
8. Control network.
9. Warning labels and signs.
10. Includes HMI Dashboard as specified in section 262300.01.

B. Drawings EP502 and EP702

1.2 DEFINITIONS

A. ATS: Acceptance Testing Specification.

B. BIL: Basic Impulse Insulation Level.

C. DDC: Direct digital control.

D. HMI: Human Machine Interface (also see OIT)

E. Legally Required: As used in this Section, it shall have the same meaning as used in NFPA 70.

F. NETA ATS: InterNational Electrical Testing Association, Acceptance Testing Specification.

G. NiCd: Nickel Cadmium.

H. OIT: Operator Interface Terminal

I. SCADA: Supervisory Control and Data Acquisition

J. SCR: Silicon-controlled rectifier.

K. SPD: Surge protective device.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data on features, performance, electrical characteristics, ratings, and finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, SCADA interface devices, Ethernet interface, and display components.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: For each medium-voltage, metal-clad switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations must show major components, features, and mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of field connection. Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Accessory information for items such as circuit breaker test set, breaker remote racking assembly, breaker lifting cart, yoke and spare equipment storage cabinet.
6. Include single-line diagram.
7. Provide dimensioned drawings and details for the HMI/OIT standalone remote cabinet.
8. Include batteries, battery rack, equipment base, charger and cell monitoring system. Provide battery sizing and load profile system report.
9. Include copy of nameplate.
10. Ratings for the switchgear assembly:

    a. Voltage.
    b. Continuous current.
    c. Short-circuit current.
    d. Lightning impulse full-wave withstand voltage.

11. Utility company's metering provisions for approval by utility company. Detailed cabinet section showing bus connections for CT’s and dimensions.
12. Include protection relay equipment information and base Relay settings used for factory testing.
13. CT, PT and LA (Lightning Arrestor) sizes and information.
14. Wiring Diagrams: For each switchgear assembly include the following:

    a. Power, signal, and control wiring.
    b. Differentiate between manufacturer-installed and field-installed wiring.

c. Three-line diagrams of circuits showing device terminal numbers and internal diagrams.
d. Schematic control diagrams.
e. Control power wiring diagrams.
f. Diagrams showing connections of component devices and equipment.
g. Communication block wiring diagram
h. Schematic diagrams showing connections to remote devices including connection details to the communications network.
i. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

15. Mimic-bus diagram.
16. Provide spreadsheet table form list identifying all the metering and status points for interrupter switches, transformers, gear devices and breakers. In table include columns for communication method and connection to locations (gear internal, remote HMI/OIT, SCADA and BMS).

C. Product Certificates: For switchgear and batteries, signed by product manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Updated mimic bus diagram reflecting field changes after final switchgear load connections have been made, for record.

B. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to Operation and Maintenance Data, include the following:

1. Manufacturer's written instructions for testing and adjusting protective relay devices.
2. Manufacturer's written instructions for sequence of operation.
3. Manufacturer's system checklists, maintenance schedule, and maintenance log sheets.
4. Lists of spare parts and replacement components recommended for storage at Project site.
5. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.

C. Software and Firmware Operational Documentation: Provide PDF files on a USB storage device.

1. Software operating and upgrade manuals.
2. Program Software Backup, complete with data files.
3. Device address list.

4. Printout/Screen Shots of software application and graphic screens.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Six of each type and rating of fuse and fusible device used. Include spares for the following:

   a. Primary disconnect fuses.
   b. Potential transformer fuses.
   c. Control power fuses.

2. Spare Indicating Lights: Six of each type installed.
3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
4. Primary Switch Contact Lubricant: One container.
5. Cabinet: Floor standing self-supporting hinged door cabinet sized to house maintenance materials, equipment O&M manuals and miscellaneous switchgear specific tools.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with install contractor to deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate with install contractor for delivery of medium voltage metal clad switchgear to allow movement into designated space.

C. Coordinate with install contractor for offloading requirements at destination.

D. Provide manufacturer's temporary heating requirement and written instructions to installing contractor.

E. Provide manufacturer's written instructions to handle switchgear splits and components. Provide factory-installed lifting provisions.

F. Provide transportation shock recorders and tilt indicators with each shipping split. Provide written tolerance requirements for each indicator type.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding 104 deg F (40 deg C).

1.8 WARRANTY

A. Manufacturer's Warranty Period: Manufacturer's maintenance and service organization shall provide a warranty of five (5) years from date of startup commissioning. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include required system hardware, software and programming updates.

E. Warranty shall include coverage for labor, material and expense costs to correct all defects.

F. Warranty requirements specified in the Owner's contract documents which are more stringent than those listed in this specification shall override these requirements.

G. Original equipment repair parts shall be available for a minimum of 10 years.

H. Special Battery Warranties: Manufacturer and Installer agree to repair or replace the switchgear control system storage batteries that fail in materials or workmanship within specified warranty period. Warranty of five (5) years from date of startup commissioning.

1. Warranted Cycle Life for Batteries: Equal to or greater than that represented in manufacturer's published table, including discharge rate, voltage and discharge cycles, based on annual average battery temperature of 77 deg F (25 deg C).

1.9 START-UP

A. Provide manufacturer certified field service technician(s) required for a complete installation. To include switchgear field programming adjustments, breaker/protection relay setting adjustments, start up, field quality control and commissioning of equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufactured Unit: Indoor, metal-clad switchgear, designed for application in solidly grounded system.

B. Comply with IEEE ANSI C37.20.2.

C. The switchgear ratings must comply with IEEE ANSI C37.04 and must be the preferred ratings of IEEE ANSI C37.06.

D. Switchgear Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory, and marked for intended location and application.

2.2 MANUFACTURERS

A. ABB / GE

B. Eaton

C. Schneider Electric / Square D

D. Siemens

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means the switchgear will remain in place without separation of any parts when subjected to the seismic forces specified and the switchgear will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Service Conditions:

1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.2.

2.4 SWITCHGEAR ENCLOSURE

A. Indoor Enclosure: Steel.

B. Enclosure Finish: Indoor Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 SWITCHGEAR CONSTRUCTION

A. Deadfront, metal-clad, draw out, switchgear assembly of vertical sections, with vacuum circuit breakers. Provide additional vertical sections to house accessories related to the switchgear functions.

1. Front and rear access switchgear.
2. Front and rear vertical section covers with hinges. The front and rear cover must be a flanged door with latching hardware. The latching hardware shall be lockable by a padlock suitable for lockout protection.
3. Infrared Window: Each breaker compartment shall contain round window ports. The ports shall be 4”. The window ports quantity and locations for each breaker must be positioned to provide optimal viewing with external infrared camera.

B. Bus: Tin-plated copper.

1. Phase Bus: 2000A, epoxy insulated bus. All bus joints shall be plated, bolted and insulated with easily installed boots.
2. Ground Bus: Sized to carry the rated short-time withstand current, extended full length of the switchgear assembly, and connected to the metal enclosures of each vertical section.
3. Grounding Stud Ball: Each rear cabinet shall include a grounding stud ball connection for safety grounding. Provide hot-stick removable insulated ball cover.

C. Circuit Breaker Compartments: Include a racking mechanism, circuit breaker operated automatic shutters covering the high-voltage bus connections, safety interlocks, and an electrical racking motor and accessories for remote racking of the circuit breaker.

1. Draw out Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.

2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts on the breaker. Disconnecting devices shall be silver plated, and engagement shall be maintained in the "connected" and "test" positions.
4. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.
5. All space for circuit breaker shall be fully bussed and dressed to receive future breakers.
6. Complete operation of the circuit breaker and trip unit must be accessible without opening the circuit breaker door.
7. Padlocking provisions shall permit locking the circuit breaker in either the “test” or “disconnected” position.
8. Safety shutters shall be provided to cover the circuit breaker primary line and load disconnects.
9. Each circuit breaker compartment shall contain a rejection feature that allows only the insertion of an intended circuit breaker.
10. All circuit breakers of like size and ratings shall be completely interchangeable.
11. Each compartment shall contain Shutter-less Wall/Barriers that provides a physical touch-safe barrier between the busbars and operator.

D. Auxiliary Vertical Sections and Compartments:

1. Utility metering compartment that complies with utility company requirements.
2. Owner's Metering: A vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.
3. Remote HMI/OIT Cabinet: Provide standalone / remote vertical section to house the remote HMI/OIT system.

    a. Provide one (1) complete stand-alone control cabinet for remote breaker operation. Cabinet shall include an HMI/OIT 24” panel with virtual breaker control and a separate hand selector trip / close switch for each breaker. For virtual control include a verification step in “Open” and “Close” sequence to avoid nuisance operations.

E. Circuit Breakers: Horizontally mounted, draw out, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

1. Electrically Operated: 125V(dc) close and trip. Powered from an external power source.

F. Accessory Set: Tools and miscellaneous items required for switchgear test, inspection, maintenance, and operation.

1. One of each size handling device to remove the circuit breaker from metal-clad switchgear and to move the breaker about on the floor. Devices include but are not limited to a floor operated portable lifting crane, breaker lifting yoke, rail extensions and dockable dolly.
2. Test cabinet with accessories to connect to the secondary contacts on an electrically operated removable element, permitting operation and testing of the removable element when it is removed from the housing.

G. Remote-Breaker Racking:

1. Provide two (2) complete automated remote racking systems for 15KV circuit breakers.
2. Remote racking device provides a means of remotely inserting or removing draw out circuit breaker in the switchgear.

a. A remote racking device shall be supplied to allow qualified personnel to rack breakers into Connect, Test and Disconnect positions from up to 25 feet away from the breaker and outside the arc flash hazard boundary.
b. The remote racking device shall support utilization on any Frame Size.
c. The remote racking device shall be portable and weigh less than 30 pounds (excluding cables and remote-control panel).
d. The remote racking device shall have integral torque overload sensing to prevent damage to the breaker racking mechanism.
e. The remote racking device shall allow breaker to be racked to any position (disconnect, test, connect) regardless of the starting position of the breaker and without the need for user input as to the starting position.
f. The 120v remote breaker racking device shall be attached to the factory mounted switchgear brackets (field retrofit capable) and secured by locking pins. No modification of the gear or circuit breakers shall be required for installation or operation.

H. Remote Breaker Operation

1. Provide one (1) complete stand-alone control cabinet for remote breaker operation. The cabinet shall include one hand selector switch for each breaker. Cabinet shall include an HMI panel with virtual control switch for each breaker. For the HMI include a verification step in “Open” and “Close” sequence to avoid nuisance operations.

I. Capacities and Characteristics:

1. Comply with IEEE ANSI C37.06.
2. Switchgear Assembly:

    a. System Voltage 13.2KV, three-phase.
    b. Rated Maximum Design Voltage and BIL (Dielectric Test): 15 kV, 95 kV.
    c. Rated Continuous Current: 2000 A.
    d. Rated Short-Circuit Current and Short-Time Current: 40 kA RMS.
    e. Power Frequency Withstand: 36KV.
    f. Momentary Current Ratings: Equal to the circuit breaker close and latch rating.

3. Circuit Breakers:

    a. Same capacities and characteristics as the switchgear assembly, and as follows:

        1) Rated Continuous Current and Load Switching Current:
            a) Main and Tie: 2000 A.
            b) Feeder: 1200A.
        2) Rated Closing and Latching Current: 104 kA, peak.
        3) Rated Interrupting Time: 50 ms.

2.6 SURGE ARRESTERS

A. Comply with IEEE ANSI C62.11, station class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

2.7 INSTRUMENTS

A. Instrument Transformers: Comply with IEEE ANSI C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

B. Power Distribution Equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet.

C. Ethernet Connectivity: Gear Supplier shall provide their standard communication network to comply with the performance of this sub-paragraph.

1. Install a multipoint, Modbus TCP communications network, by suppling manufacturer standard within the switchgear to interconnect all breaker trip units, and metering devices equipped with communications.
2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web

pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.

3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-T LAN.
4. All serial communications devices within the equipment shall be addressed at the factory and tested.
5. The supplier has option to provide Modbus TCP/IP over Ethernet direct to each breaker in lieu of serial Modbus and gateways.

D. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Three-Phase Apparent Power: Plus or minus 2 percent.
    g. Power Factor: Plus or minus 2 percent.
    h. Frequency: Plus or minus 0.5 percent.
    i. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    j. Energy: Watts, Watt Demand, Watt-hours, VARs, VAR Demand, VAR-Hour, VA, VA Demand and VA-Hour.
    k. Accumulated energy, in megawatt-hours (megajoules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Event Waveform Capture shall record the voltage and current waveforms for each event exceeding settable thresholds. stored values unaffected by power outages for up to 72 hours.
4. Communications module suitable for remote monitoring of meter quantities and functions. Information to be communicated in Modbus TCP/IP over Ethernet. Connections to HMI / OIT, SCADA, BMS and downloadable to USB Drive.
5. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.
6. Provide metering for each circuit breaker installed.

E. Analog Instruments: Rectangular, 4-1/2 inch (115 mm) square, 1 percent accuracy, semi flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase voltages.

3. Locate meter and selector switch on circuit-breaker compartment door for Main and Tie Breakers only.

2.8 PROTECTIVE RELAYS

A. Multifunctional, solid-state microprocessor-based relay systems, complying with IEEE ANSI C37.90.

B. Relay Mounting:

1. Each relay must be mounted in a draw out case with a two-stage quick-release operation.
2. Removal of the relay from the case must disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.
3. When the relay is inserted into the case, control power connections must be made before the trip circuits are activated.
4. Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.
5. Provide required CT and PT and wiring to each digital protective relay.
6. Provide fiber optic arc flash detection sensors, wiring and connections as required for arc flash detection coverage of each corresponding side of the switchgear. Set for flash and current rate of rise.
7. Provide maintenance setting switch on protective relay to reduce arc flash hazard when the switch is in the maintenance mode position.
8. Manufacturer must provide initial protection relay settings to complete factory testing.
9. The manufacturer field technician onsite must complete relay setting adjustments required to meet the field quality control startup and commissioning.

C. Each relay system must include a communications module to transmit data.

1. Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
2. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

D. Overcurrent and Ground-Fault Protective Relays:

1. IEEE ANSI C37.2 and ANSI device functions as specified for each type of load. The basis of design manufacturer is SEL.
2. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.
3. Primary Current-Transformer Ratings: Programmable from 5 to 2000 A.
4. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
5. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent

has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and must be deactivated after approximately eight cycles.

6. Contacts:

    a. Two Form-A contacts.
    b. Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

        1) One contact assigned function 51 phase and function 51 ground, and the other contact assigned function 50 phase and function 50 ground.
        2) One contact assigned function 51/50 phase, and the other contact assigned function 51/50 ground.

7. Alphanumeric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current-causing trip.
    e. Phase or ground indication.
    f. Peak current demand for each phase and ground since last reset.
    g. Current-transformer primary rating.
    h. Programmed phase and ground set points.

8. Relay alarm and trip contacts must not change state if power is lost or an undervoltage occurs. These contacts must only cause a trip on detection of an overcurrent or fault condition based on programmed settings. A "protection off" alarm must be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this alarm relay must be de-energized, providing a fail-safe protection off alarm.

E. Switchgear shall include following type, rating and protection relay: SEL Relays identified as Base-Line.

1. Main Circuit Breaker: SEL 751A - ANSI 25, 27, 47, 50/51P, 50/51N, 50/51G, 50 PAF, 62, 86, and 87B.
2. Feeder Circuit Breaker: SEL 751A - ANSI 50/51P, 50/51G, 50 PAF, 62, and 86.
3. Tie Circuit Breaker: SEL 751A - ANSI 50/51P, 50/51G, 50 PAF, 62, and 86.

F. Power Transfer Configuration for Main – Tie – Main:

1. Automatic Transfer Control: Must have a microprocessor-based automatic transfer control scheme with auto/manual selector.
2. Factory-installed and tested controls of circuit breakers to accomplish automatic transfer controls for switchgear having two main utility power sources.

    a. Normal operation is Dual Utility source: Tie “Open”, both Mains “Closed” operating on Utility power.

b. Single Utility source outage: “Open” Main of lost Utility and “Close” Tie to feed across the bus from single Utility source. Closing of the Tie shall be time delayed coordinating with the emergency generator sequencing. Time delay shall be adjustable between 0 and 180 seconds.
c. Dual Utility source outage: “Open” Mains, Tie “Open”, standby for Utility return.

3. Power for the transfer control shall be from the voltage sensing transformers.
4. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative sequence voltage protection.
5. The transfer control system shall be indicated on the HMI dashboard. The dashboard shall show the status of the system as it is operating. When timers are functioning, the dashboard shall show the timer counting down.

G. Arc Flash protection shall be provided by the protection relay. System shall include one style or a combination of both fiber optic cable and fiber optic point sensors. Trip identification shall include both light flash and current rate of rise.

H. Indicating Lights: To indicate circuit breaker is open or closed.

2.9 DC CONTROL POWER SUPPLY

A. Manufacturers:

1. EnerSys
2. Saft
3. SBS
4. SENS
5. Approved Equal

B. Dedicated 125 V(dc) battery system.

C. System Requirements: Battery must have number of cells and ampere-hour capacity based on an initial specific gravity at 77 deg F (25 deg C) with electrolyte at normal level and minimum ambient temperature of 55 deg F (13 deg C). Cycle battery before shipment to guarantee rated capacity on installation. Arrange to operate ungrounded. Battery system capacity must be as recommended by switchgear manufacturer to operate the circuit breakers and switchgear control for intended duty.

1. Battery system must be fully redundant with separate battery racks and chargers. Each system sized for 100% operation.

a. Size system for two complete trip charge operations for each breaker. Once at loss of Utility power and once after eight hours of maintained steady state operation.

2. Provide battery sizing and load profile system report.

D. Battery: Ni-Cd system is the basis of design. Li-ion system is an acceptable alternative.

1. Batteries, with system disconnect and overcurrent protective device.
2. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.
3. Accessories: Set of battery cell numerals.
4. Charger: Solid State Switched Mode Tpe, equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit must automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

    a. DC ammeter.
    b. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
    c. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
    d. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
    e. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation must be automatic until manually reset.
    f. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3 Hz variation in frequency. Automatic charger operation must resume after loss of ac power supply for interval.
    g. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device must regulate charging current but must not disconnect charger from either battery or ac supply.
    h. Charger's Audible Noise: Less than 26 dB.

E. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

F. Battery Cell Monitoring System with normal/trouble/alarm communication to SCADA and BMS systems.

G. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

1. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
2. Conductors: Sized in accordance with NFPA 70 for duty required.

2.10 CONTROL NETWORK

A. Compliance with ASHRAE 135: Controllers must support serial MS/TP and Ethernet IP communications and must be able to communicate directly via TIA-485 serial networks and Ethernet 10Base-T networks as a native device.

2.11 IDENTIFICATION, WARNING LABELS AND SIGNS

A. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for OSHA 29 CFR 1910.269.

1. Warning signs must be baked enamel signs.
2. Equipment Identification Labels: Laminated acrylic or melamine plastic signs.

B. Compartment Nameplates: Engraved, metal nameplate for each compartment, mounted with corrosion-resistant screws.

C. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Color: Contrasting with factory-finish background.

2.12 SOURCE QUALITY CONTROL

A. Perform production tests on each circuit breaker housing for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
2. Conduct an alignment test with master circuit breaker to verify interfaces.
3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
4. Perform the control wiring dielectric test at 1500 V for one minute.
5. Perform the dielectric test on primary and secondary circuits.

B. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of the switch.
2. Conduct an alignment test with master cell to verify interfaces and interchangeability.
3. Verify the contact gap. Perform terminal-to-terminal resistance test.

4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.
5. Perform the control wiring dielectric test at 1500 V for one minute.
6. Set the contact gap.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Provide factory certified technician(s) to complete tests, adjustments and inspections. See above, Part 1 - 1.08 Warranty and Part 1 – 1.09- Start-Up.

3.2 SYSTEM FUNCTION COMMISSIONING TESTS

A. Manufacturer's Field Service: Provide factory-authorized service technician(s) to provide startup and commissioning of switchgear.

1. Services to include service technician(s) being on site as each circuit breaker is energized to test programing and functionality.
2. Test automatic transfer control scheme.
3. Provide documentation confirming results of testing.
4. Provide field programming and relay setting adjustments required to complete field quality control, startup and commissioning.

B. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Provide test parameters documents and submit to Owner/Project Representative minimum of eight (8) weeks prior to testing for review and approval.
2. Perform approved submittal tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
3. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
4. Verify the correct operation of sensing devices, alarms, and indicating devices.

C. Provide complete startup and commissioning test report for switchgear.

3.3 FACTORY WITNESS TEST

A. The medium voltage switchgear manufacturer shall include in the proposal a factory witness test that provides testing of the switchgear lineup, including failure recovery operations. The manufacturer shall provide the ability to simulate source loss, circuit

breaker failure and undervoltage and overload events. Factory testing schedule shall be provided minimum of four weeks prior to testing for coordination of travel accommodations. The proposal shall include Owner travel expenses:

1. Include costs associated with Owner travel expense to witness factory testing. Total value attributed to travel expense shall be clearly indicated.
2. Expenses shall include roundtrip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for two Owner Representatives, with origin of Indianapolis, IN.

END OF SECTION 261326

SECTION 261326 - MEDIUM-VOLTAGE METAL-CLAD SWITCHGEAR - INSTALL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Installation of Medium Voltage Switchboards

B. Related Requirements:
   1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   2. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in switchgear.

1.2 DEFINITIONS

A. NETA ATS: International Electrical Testing Association, Acceptance Testing Specification.

1.3 SUBMITTALS

A. Product Data: For each type of product.

   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Field Connection Wiring Diagrams: Power, signal, and control wiring.
   2. Dimensioned plans and elevations showing major components and features.

      a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
   3. One-line diagram.
   4. List of materials.
   5. Nameplate legends.

C. Field quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of switchgear to allow movement into designated space.

C. Store switchgear components protected from weather and so condensation does not form on or in units. Provide temporary heating in accordance with manufacturer's instructions.

D. Handle switchgear components in accordance with manufacturer's instructions. Use factory-installed lifting provisions.

1.5 WARRANTY

A. Installer’s Warranty Period: Provide a warranty for one year from the date of substantial completion. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include coverage for labor, material and expense costs to correct all defects.

E. Warranty requirements specified in the Owner’s contract documents which are more stringent than those listed in this specification shall override these requirements.

PART 2 - PRODUCTS

2.1 Provide Gear Maintenance Cabinet: Identified and compartmented steel cabinet with lockable hinged doors. Sized for breaker remote racking out devices, breaker test devices, flexible cord sets and miscellaneous gear equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.

1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.
2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and shop drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
5. Unload switchgear, observing packing label warnings and handling instructions.
6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle switchgear in accordance with manufacturer's recommendations, avoid damage to the enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
2. Protect switchgear compartments against the entrance of dust, rain, and snow.
3. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
4. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
5. Do not damage structure when handling switchgear.

C. Storage:

1. Store switchgear in a location that is clean and protected from weather. Protect switchgear from dirt, water, contamination, and physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
2. Store switchgear with compartment doors closed.
3. Regularly inspect switchgear while in storage and maintain documentation of storage conditions, noting discrepancies or adverse conditions.

D. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

E. Pre-Installation Checks:

1. Verify removal of shipping bracing after placement.

F. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 ohms ohms at switchgear location.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SWITCHGEAR

A. Comply with the provisions of IEEE ANSI C37.20.2 subclause titled "Guide for Handling, Storage, and Installation."

B. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). See structural sheets for equipment base details.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Comply with requirements for vibration isolation devices specified in Section 260529 "Hangers and Supports for Electrical Systems."

C. Switchgear must be installed level and plumb. Switchgear must tilt less than 1.5 degrees while energized.

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's written instructions and NFPA 70.

E. Comply with NECA 430.

3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable not smaller than No. 4/0 AWG for grounding cabling to grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

D. Complete switchgear grounding and lightning arrester connections prior to making other electrical connections.

E. Terminate medium-voltage cables in accordance with Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Construction Manager Project Representative.

B. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

C. Medium-Voltage Switchgear Assembly Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
b. Verify that current and voltage transformer ratios correspond to Drawings.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Inspect insulators for evidence of physical damage or contaminated surfaces.
g. Verify correct barrier and shutter installation and operation.
h. Exercise active components.
i. Inspect mechanical indicating devices for correct operation.
j. Verify that filters are in place and vents are clear.
k. Perform visual and mechanical inspection of instrument transformers in accordance with "Instrument Transformer Field Tests" Paragraph.
l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.

e. Control Power Transformers:

1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at devices.
3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

f. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

g. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Perform system function tests in accordance with "System Function Tests" Article.
i. Verify operation of space heaters.
j. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism must be in accordance with manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values must not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the trip and close coils must comply with manufacturer's published data. In the absence of the manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer's published data.
e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.

f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values must comply with manufacturer's published data.
g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.
h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
i. Verify operation of heaters.

E. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.
c. Verify correct connection of transformers with system requirements.
d. Verify that adequate clearances exist between primary and secondary circuit wiring.
e. Verify the unit is clean.
f. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
g. Verify that required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of

insulation resistance less than manufacturer's written recommendations or NETA ATS, Table 100.5.

c. Perform a polarity test of each current transformer in accordance with IEEE ANSI C57.13.1. Polarity results must agree with transformer markings.

d. Perform an excitation test on transformers used for relaying applications in accordance with IEEE ANSI C57.13.1. Excitation results must match the curve supplied by the manufacturer or be in accordance with IEEE ANSI C57.13.1.

e. Measure current circuit burdens at transformer terminals in accordance with IEEE ANSI C57.13.1. Measured burdens must be compared with and must match instrument transformer ratings.

f. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages must be in accordance with Table 100.5.

g. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages must be in accordance with Table 100.9.

h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.

i. Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

3. Electrical Tests of Voltage Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages must be applied for one minute in accordance with Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.

c. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable. Polarity results must agree with transformer markings.

d. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared with and must match instrument transformer ratings.

e. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.

f. Verify that voltage transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. Test results must indicate that the circuits are grounded at only one point.

F. Ground Resistance Test:

1. Visual and Mechanical Inspection:

a. Verify ground system complies with Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections must be free of corrosion.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
d. Inspect anchorage.

2. Electrical Tests:

a. Perform fall-of-potential or alternative test in accordance with IEEE Std 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground must be no more than 5 ohms.
b. Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohm. Compare equipment nameplate data with Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using a low resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

G. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

    a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
    c. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
    d. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
    e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results must confirm the integrity of the secondary circuits of current and voltage transformers.

H. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

    a. Verify that equipment nameplate data complies with Contract Documents.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding, and clearances.
    d. Verify the arresters are clean.
    e. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
    f. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

2. Electrical Test:

    a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.
    b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
    c. Test grounding connections. Resistance between the arrester ground terminal and the ground system must be less than 0.5 ohm.

I. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

    a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
    b. Verify operation of light-emitting diodes, display, and targets.
    c. Record passwords for each access level.
    d. Clean the front panel and remove foreign material from the case.

e. Check tightness of connections.
f. Verify that the frame is grounded in accordance with manufacturer's instructions.
g. Set the relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.
b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) Sync Check Relay:

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

4) Undervoltage Relay:

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on the timing curve for inverse time relays.

5) Directional Power Relay:

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.

c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on the timing curve for inverse time relays.

6) Current Balance Relay:

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

7) Negative Sequence Current Relay:

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on the I-two-squared-t curve.

8) Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.

9) Time Overcurrent:

a) Determine minimum pickup.
b) Determine time delay at two points on the time current curve.

10) Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

11) Directional Overcurrent Relay:

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine overcurrent unit pickup.
d) Determine overcurrent unit time delay at two points on the time current curve.

d. Control Verification:

1) Functional Tests:

a) Check operation of active digital inputs.
b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.

c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

J. DC System Vented NiCd Batteries Field Test:

1. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify equipment nameplate data complies with Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify electrolyte level. Measure pilot-cell electrolyte temperature, and correct as recommended by manufacturer's maintenance procedures to bring the temperature and electrolyte level to within normal limits.
h. Verify the units are clean.
i. Inspect spill containment installation.
j. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and that alarms comply with system manufacturer's recommendations.
c. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published data.
d. Measure intercell connection resistances.
e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
f. Perform a load test in accordance with manufacturer's published data or IEEE Std 1106. Replace units that fail to pass the test.
g. Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive-to-ground must be equal in magnitude to the voltage measured from negative to ground.

K. Nonconforming Work:

1. Switchgear will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

L. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.6 SYSTEM FUNCTION TESTS

A. System function tests must prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, if requested by Owner, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each switchgear. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

    a. Adjust switchgear taps.
    b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.
4. Report:

    a. Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove covers prior to the inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 86 deg F.

3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used and lists the results as follows:

    a. Description of equipment to be tested.
    b. Discrepancies.
    c. Temperature difference between the area of concern and the reference area.
    d. Probable cause of temperature difference.
    e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
    f. Identify load conditions at time of inspection.
    g. Provide photographs and thermograms of the deficient area.

4. Act on inspection results in accordance with the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION 261326.1

SECTION 261327 - MEDIUM-VOLTAGE PARALLELING METAL-CLAD SWITCHGEAR - PURCHASE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Switchgear enclosure.
2. Switchgear construction.
3. Surge arresters.
4. Instruments.
5. Protective relays.
6. Control power supply.
7. Battery system control power supply.
8. Control network.
9. Warning labels and signs.

B. Drawings EP-701, EP-703 and EP-505. Drawing EP-716 included for SCADA system connections.

C. Related Documents:
1. Section 263213.13 Diesel-Engine-Driven Generator Sets.
2. Section 261327.11 Sequence of Operation
3. Section 262300.01 HMI Dashboard System

1.2 DEFINITIONS

A. ATS: Acceptance Testing Specification.

B. BIL: Basic Impulse Insulation Level.

C. DDC: Direct digital control.

D. HMI: Human Machine Interface (also see OIT)

E. Legally Required: As used in this Section, it shall have the same meaning as used in NFPA 70.

F. NETA ATS: InterNational Electrical Testing Association, Acceptance Testing Specification.

G. NiCd: Nickel Cadmium.

H. OIT: Operator Interface Terminal

I. SCADA: Supervisory Control and Data Acquisition

J. SCR: Silicon-controlled rectifier.

K. SPD: Surge protective device.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data on features, performance, electrical characteristics, ratings, and finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, SCADA interface devices, Ethernet interface, and display components.
2. Include rated capacities, operating characteristics, furnished specialties, factory settings, and accessories.
3. Time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: For paralleling medium-voltage, metal-clad switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations must show major components, features, and mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection. Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Accessory information for items such as circuit breaker test set, breaker remote racking assembly, breaker lifting cart, yoke and spare equipment storage cabinet.
6. Include single-line diagram.
7. Provide dimensioned drawings and schematic details for the low voltage Master, Generator, HMI/OIT standalone control cabinets.
8. Include batteries, battery rack, equipment base, charger, and cell monitoring system. Provide battery sizing and load profile system report.
9. Include copy of nameplate.
10. Include Mimic Bus Diagram.
11. Ratings the switchgear assembly:

    a. Voltage.
    b. Continuous current.
    c. Short-circuit current.
    d. Lightning impulse full-wave withstand voltage.

12. Include Protection Relay equipment information and base relay settings used for factory testing.

13. CT, PT and LA (Lightning Arrestor) sizes and information.
14. Wiring Diagrams: For each switchgear assembly include the following:

    a. Power, signal, and control wiring.
    b. Differentiate between manufacturer-installed and field-installed wiring.
    c. Three-line diagrams of circuits showing device terminal numbers and internal diagrams.
    d. Schematic control diagrams.
    e. Control power wiring diagrams.
    f. Diagrams showing connections of component devices and equipment.
    g. Communication block wiring diagram
    h. Schematic diagrams showing connections to remote devices including connection details to the communications network.
    i. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

15. Include point-to point schematic control, monitoring, and alarm wiring diagrams for external components indicating terminal numbers for the following:

    a. Engine generators.
    b. Medium and Low Voltage automatic transfer switches.
    c. SCADA remote terminal unit.
    d. SCADA remote workstation.

16. Provide spreadsheet table form list identifying all the metering and status points for generators, gear devices and breakers. In table include columns for communication method and connection to locations (gear internal, remote HMI/OIT, SCADA and BMS).

17. Provide Load Bank information, detailed and dimensioned drawings, and schematic diagrams for power, control and communications.

C. Sequence of Operation: Description of sequence of operation for paralleling controls in automatic, manual and system test modes.

1. Include the following in the description of the automatic-mode sequence of operation:

    a. Programmed sequence of initial generator starting and connection of generators to the isolated paralleling bus, including a description of how the proposed design complies with the requirements for redundancy.
    b. Programmed sequence of transferring loads to the isolated paralleling bus based on operator-adjustable preset priorities and preset loads. Include initial load settings.
    c. Programmed sequence of starting and stopping generators based on actual real-time measured loads.
    d. Programmed sequence of sending a load-shed signal when the

generator frequency does not return to the normal frequency within the adjustable time period.

e. Programmed sequence of stopping generators based on no transfer switch or other device sending a start signal.

2. Include the following in the description of the system testing mode sequence of operation:

   a. Load.
   b. No load.

3. Include in the description, the manual-mode sequence of operation showing that the manual mode fulfills the requirement to permit the operator at the paralleling switchgear control to accomplish all automatic, system test, and load shedding functions.
4. Provide failure recovery operations for each switchgear sequence. Failure recovery shall include the following:

   a. Feeder Breaker Fail to Open
   b. Feeder Breaker Fail to Close
   c. Tie Circuit Breaker Fail to Open
   d. Tie Circuit Breaker Fail to Close
   e. Generator Paralleling Circuit Breaker Fail to Open
   f. Generator Paralleling Circuit Breaker Fail to Close
   g. Generator Fail to Synchronize
   h. Extended Parallel Event
   i. Underfrequency/Overload Event

5. Provide a power control system sequencer that provides a scripted representation of the sequence of operations, including failure recovery operations.

D. Paralleling Switchgear Redundancy: Identify any single points of failure.

E. Product Certificates: For switchgear and batteries, signed by product manufacturer.

F. Source quality-control reports.

G. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Updated mimic bus diagram reflecting field changes after final switchgear load connections have been made, for record.

B. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to Operation and Maintenance Data, include the following:

1. Manufacturer's written instructions for testing and adjusting protective relay devices.
2. Manufacturer's written instructions for sequence of operation.
3. Manufacturer's system checklists, maintenance schedule, and maintenance log sheets.
4. Lists of spare parts and replacement components recommended for storage at Project site.
5. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.

C. Software and Firmware Operational Documentation: Provide PDF files on a USB storage device.

1. Software operating and upgrade manuals.
2. Program Software Backup, complete with data files.
3. Device address list.
4. Printout/Screen Shots of software application and graphic screens.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Six of each type and rating of fuse and fusible device used. Include spares for the following:

    a. Primary disconnect fuses.
    b. Potential transformer fuses.
    c. Control power fuses.

2. Spare Indicating Lights: Six of each type installed.
3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
4. Primary Switch Contact Lubricant: One container.
5. Cabinet: Floor standing self-supporting hinged door cabinet sized to house maintenance materials, equipment O&M manuals and miscellaneous switchgear specific tools.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with install contractor to deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate with install contractor for delivery of medium voltage paralleling metal clad switchgear to allow movement into designated space.

C. Coordinate with install contractor for offloading requirements at destination.

D. Provide manufacturer's temporary heating requirement and written instructions to installing contractor.

E. Provide manufacturer's written instructions to handle switchgear splits and components. Provide factory-installed lifting provisions.

F. Provide transportation shock recorders and tilt indicators with each shipping split. Provide written tolerance requirements for each indicator type.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding 104 deg F (40 deg C).

1.8 WARRANTY

A. Manufacturer’s Warranty Period: Manufacturer’s maintenance and service organization shall provide a warranty of seven (7) years from date of startup commissioning. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include required system hardware, software and programming updates.

E. Warranty shall include coverage for labor, material and expense costs to correct all defects.

F. Warranty requirements specified in the Owner’s contract documents which are more stringent than those listed in this specification shall override these requirements.

G. Original equipment repair parts shall be available for a minimum of 10 years.

H. Special Battery Warranties: Manufacturer and Installer agree to repair or replace the switchgear control system storage batteries that fail in materials or workmanship within specified warranty period. Warranty of seven (7) years from date of startup commissioning.

1. Warranted Cycle Life for Batteries: Equal to or greater than that represented in manufacturer's published table, including discharge rate, voltage and discharge cycles, based on annual average battery temperature of 77 deg F (25 deg C).

1.9 START-UP

A. Provide manufacturer certified field service technician(s) required for a complete installation. To include switchgear field programming adjustments, breaker/protection relay setting adjustments, master paralleling controller field programming adjustments, start up, field quality control and commissioning of equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufactured Unit: Indoor, medium voltage, paralleling metal-clad switchgear, designed for application with a neutral grounding resistor system. Referred to as paralleling medium voltage switchgear.

B. Comply with IEEE C37.20.2.

C. The switchgear ratings shall comply with IEEE C37.04 and shall be the preferred ratings of IEEE C37.06.

D. Switchgear Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified electrical testing laboratory, and marked for intended location and application.

E. The multiple-generator paralleling monitoring and control panel in the paralleling medium-voltage switchgear shall monitor and control the following standby power system components:
1. Paralleling medium-voltage switchgear.
2. Single-generator paralleling monitoring and control systems that are part of the paralleling medium-voltage switchgear.
3. Engine generators.
4. Transfer switches.
5. Other load-control devices.
6. Distribution circuit breakers in paralleling medium-voltage switchgear.
7. Inhibit control to automatic transfer controller of Unit Substations. Used to hold Tie transfer during emergency operation or as system directed.

F. Redundant Standby Power System:
1. Black-start controller with a backup controller in the paralleling medium voltage switchgear.
2. Multiple-generator paralleling monitoring and control system shall automatically be performed by a backup system without degradation in the event that primary system fails to function for any reason (such as component failure or off-line maintenance).

G. Sequence of Operation: See Section 261327.11 Sequence of Operations

H. Comply with NFPA 110 for the following:

1. Emergency: EPSS Level 1, Type 10.
2. Legally Required Standby: EPSS Level 1, Type 60.
3. Optional Standby: EPSS Level 1, Type 60.

2.2 MANUFACTURERS

A. Paralleling MV Switchgear:

1. ABB – Zenith
2. ASCO
3. Russelectric

B. Source Limitations: Paralleling medium-voltage switchgear must be a complete engineered system coordinated with the following generator and MV switchgear breakers and components and protective relays.

1. Generators:

    a. Caterpillar
    b. Cummins
    c. Kohler
    d. MTU

2. MV Switchgear Breakers and Components:

    a. ABB / GE
    b. Eaton
    c. Schneider Electric (Square D)
    d. Siemens

3. Protection Relays:

    a. ABB
    b. Multilin
    c. S.E.L (Schweitzer Engineering Laboratories)

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means the switchgear will remain in place without separation of any parts when subjected to the seismic forces specified and the switchgear will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Service Conditions:

1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.2.

2.4 MULTIPLE-GENERATOR PARALLELING MONITORING AND CONTROL SYSTEM

A. Components and Devices: Factory mounted in a metal-clad, paralleling medium-voltage switchgear.

1. Paralleling Medium-Voltage Switchgear Door-Mounted Control Devices: Industrial, watertight and oil-tight type devices.
2. Indicator Lamps: LED type.
3. High-intensity digital display units

B. Control Power for Multiple-Generator Monitoring and Control System: Supplied from dual redundant 125-V dc battery system.

1. Isolate each battery bank to prevent failure of one battery from disabling entire system.
2. The paralleling switchgear controls, including and not limited to: HMI, Master PLC's and I/O, generator PLC's, I/O shall be configured such that the primary control power is obtained from the 125VDC station battery systems.
3. In the event of a loss of all 24VDC redundant power from the auxiliary generators, the system shall continue to operate without failure, this includes all generator starting functions, control operation,
4. Include, if necessary, separate dual redundant control power battery system rated 24-V dc for equipment unable to accept voltage drop that occurs during engine cranking.

C. Redundant Multiple-Generator Monitoring and Control System Controller (HMI/OIT):

1. Master PLC Redundancy

    a. This system shall consist of identical and synchronized redundant programmable logic controllers and common distributed I/O systems between the controllers. Normally, the primary controller shall be the active one that controls the system I/O while secondary controller(s) shall be on standby, ready to take control of the system I/O. Any single failure to the active controller shall cause automatic switch over to the standby controller. As both controllers shall be synchronized, there shall be a transfer from one controller to the other without interruption. The I/O shall be held in their current state during the transfer.
    b. If the active controller fails and control transfers to the standby controller, the failed controller can be turned off and repaired without affecting the rest of the system.
    c. Status indicators shall indicate which controller is active and if a controller is in run or stop mode.

2. Redundant I/O

a. I/O shall be redundant and connected to the PLC's through a managed Ethernet ring communication network. Loss of a single I/O module shall be annunciated but have no impact on the performance of the system. The loss of dual IO modules or the communication network shall be annunciated, and the system shall revert to manual mode.

3. Fully equip with hot swappable programmable logic controller, power supplies, and I/O points.
4. Coordinate with black-start control equipment specified in applicable engine generator Section.
5. Programming for the sequence of operations shall be completed and tested at the factory.
6. Provide a factory field technician to complete programming field adjustments required during field quality control startup and commissioning.

D. Master Multiple-Generator Monitoring and Control System Controller (HMI/OIT):

1. Main purpose is monitor and control of complete emergency power system.
2. Remote breaker operation of the MV Paralleling Switchgear outside of arc flash boundary.

E. Multiple-generator monitoring and control system selector switches and pushbuttons

1. System Mode Selector Switch: Auto-Manual
2. Alarm Silence Pushbutton
3. Bus Reset Pushbutton
4. Transfer Initiate Pushbutton
5. Transition Mode Selector Switch: Open-Closed
6. Building Load Test Selector Switch: Bus A-Bus B-Full
7. Load Bank control selector switch.
8. No Load Test Selector Switch: On-Off
9. Load Shed Pushbutton (1 for each priority block)
10. Manual Parallel Pushbutton (manual paralleling)
11. Manual Parallel Selector Switch (manual paralleling)

F. Manual Paralleling

1. A Synchroscope selector switch shall be provided to select any generator for manual paralleling operation. The positioning of the selector switch shall simultaneously connect the synch-check relay, Synchroscope, and "manual paralleling" push-button to the selected generator.
2. A solid-state sync check relay shall be furnished for manual paralleling, to sense and compare the phase angle difference between the oncoming generator and the bus. This relay shall lockout the manual paralleling push-button until the oncoming generator is within 15 degrees of synchronism.
3. Operation shall be arranged so the operator shall depress and hold the manual paralleling push-button. When the relative phase angle reduces to 15 degrees and going towards zero degrees, the sync check relay's output contact shall initiate the closing of the respective oncoming generator breaker.

4. The manual paralleling interface controls and metering shall be grouped in a central location on the front of the master control section. This shall allow for paralleling multiple generators from one location within the switchgear. Manual paralleling controls and sync check relay shall be hardwired and shall not rely on touch screens or programmable logic controllers to perform manual paralleling functions.

G. Control switch for circuit breaker that serves load bank connection.

H. HMI/OIT Dashboard System

1. Full-Color, Touch-Screen, Human-Machine Interface Device:

    a. Minimum viewing area of 24” diagonal at 1920x1080 resolution shall be configurable in either U.S. standard or SI (metric) units.

2. The HMI shall have minimum 3.2 GHz dual core CPU with integrated HD Graphics card, intel core i5,8 GB DDR4 RAM, 500 GB solid state drive, win 7 Pro 64 bit, window 10.
3. The HMI shall have minimum of two Ethernet and USB interfaces.
4. The HMI shall support and external memory card for additional storage in addition to device’s internal DDR4 memory.
5. The HMI shall support intuitive multi-touch functionality permitting user to zoom, scroll and swipe.
6. Include power monitoring software with clients, web client, and device licenses.
7. Graphic package for ATO and breaker operation.
8. The HMI/OIT Dashboard shall be mounted in the master control cabinet.
9. The HMI/OIT Dashboard shall use CAT6 as physical media to communicate with electronic components located in the switchgear either via an Ethernet switch or the manufacturer Gateway. Modbus-TCP/IP over Ethernet shall be preferred communication protocol between the component interface to the HMI/OIT.
10. The HMI Dashboard must support multiple security levels such as Administrator and multiple users so that appropriate operational rights can be assigned to an operator.
11. Main Menu: Include date, time, and system status messages. Configure screens so that no screen is more than three touches from any other screen.

    a. Individual engine generator data shall be accessed at the paralleling medium-voltage switchgear generator control cabinets from the main menu and each single-generator paralleling monitoring and control system.

12. One-Line Diagram: Depicting system configuration and system status by screen animation, screen colors, text messages, or pop-up indicators.

    a. Conditions for Engine Generators, Buses, and Paralleling Circuit Breakers: Energized or de-energized.
    b. Engine Generator Modes:
    1) Auto.
    2) Lockout.

3) Reset.
4) Off.
5) Cool down.
6) Test off line.
7) Test on load.

c. Engine Generator Status: Normal, warning, shutdown, or load-demand stop.
d. Paralleling Circuit-Breaker Status: Open, closed, or tripped.
e. Bus Conditions: Energized or de-energized.
f. Percent load.

13. AC metering screen for each bus and each breaker shall display the following:

a. Phase, volts, and amperes.
b. Kilowatts.
c. Kilovolt amperes.
d. Kilovolt-ampere rating.
e. Power factor.
f. Frequency.
g. Kilowatt hour.
h. Kilowatt demand.
i. Real-time trend chart for system kilowatts and volts updated on not less than one-second intervals.
j. A minimum of one historical trend chart for total system loads with intervals no shorter than five minutes and a minimum duration of four hours.
k. Percent of available capacity of the engine generators that are operating in parallel on the bus.

14. Engine Generator Monitoring and Control Screen:

a. Control:

1) Engine generator manual start/stop control (functional only when the paralleling low-voltage switchgear mounted control switch is in "Auto" position).
2) Engine generator alarm reset.
3) Manual paralleling and circuit-breaker enable/inhibit controls.
4) Engine function and timer settings.
5) System function, testing, and timer settings.
6) Engine generator optimization settings: automatically determine the priority of the engine generators based on engine run time and number of engine starts or manually assign engine priorities.

b. Status and Alarms:

1) Power Metering: Watts, volt-ampere reactive, power factor, frequency, amperes, and voltage.
2) Engine run hours.

3) Engine status.
4) Number of generator circuit-breaker operations.

15. Dual, Three-Phase, Metering Screen: Graphical analog (270 electrical degree) metering representation with digital display. Display two generators at the same time or one generator and the isolated paralleling bus at the same time. Display graphical synchroscope when one generator and the isolated paralleling bus are selected.

    a. True rms, three-phase voltage, amperes, kilowatts, kilovolt amperes, kilovolt-ampere reactive, power factor, and frequency parameters.
    b. Engine battery voltage display.

16. Password-Protected System Control Screen:

    a. System Test Modes: Test with load/test without load/normal/retransfer time-delay override.
    b. Test with Load: Starts and synchronizes engine generators on isolated paralleling bus; all loads are transferred to the isolated paralleling bus.
    c. Test without Load: Starts and synchronizes engine generators on isolated paralleling bus but does not transfer loads to the isolated paralleling bus.
    d. Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.

17. Load-Demand Control Screen: Monitors total load on the isolated paralleling bus and controls number of engine generators running so that capacity tracks load demand.

    a. Load-Demand Control: Enable/disable.
    b. Set engine generator shutdown sequence.
    c. Load-Demand Pickup Set Point: Adjustable from 90 to 40 percent in 5 percent increments.
    d. Load-Demand Dropout Set Point: Adjustable from 20 to 70 percent in 5 percent increments.

18. Manual Load Control Screen: Allows operator to manually add or delete engine generators from paralleled system in response to system load parameters.

    a. Indication of system available in kilowatts and amperes.
    b. Control functions allow manual addition/removal of engine generators on system, and activation of load-shed/load-restore functions.

19. Load-Add/Load-Shed Sequence Screen: Password protected and with the following minimum functions:

    a. Display sequence.
    b. Assigns "load-add sequence priority" to each load-control relay with designation for relay operation after a set number of engine

generators are online.

c. Assigns "load-shed sequence priority" to each load-control relay with designation for relay operation depending on number of engine generators online.

20. Alarm Summary and Run Report Screen:

a. Lists most recent alarm conditions and status changes.
b. Lists a minimum of the most recent 32 alarm conditions by name and time/date; acknowledges alarm conditions with time/date.
c. For each start signal, lists start time and date, stop time and date, maximum kilowatt and ampere load on system during run time, and start and stop times of individual engine generators.
d. Lists generator circuit position and status.
e. Access to trend all monitored automatic transfer switches.
f. 512-gigabyte solid state drive space for storing the database file for multiple-generator paralleling monitoring and control panel trending and event logging. Trend and log data at a resolution of one second. If hard drive is full, overwrite in a first-in-first-out procedure.

1) Trend up to eight monitored points simultaneously.

21. Load Status and Control Screen: Displays status of automatic transfer switches, and other controlled devices connected to the system.

a. Fire Pump Controller Transfer Switch connected to normal.
b. Fire Pump Controller Transfer Switch connected to emergency.
c. Paralleling switchgear tie breaker, open or closed.
d. Transfer switches connected to normal.
e. Transfer switches connected to emergency.
f. Transfer switch loss of power indication and generator start enable signal.
g. Engine start indication.
h. Load-shed indication.
i. Load-add indication.
j. Circuit Breaker Power Metering Function: Total kilowatt, three-phase current, and three-phase voltage.
k. Load Priority: Ability to change priorities. (password protected).
l. Display name, status, and priority of each load block (whether on or off) and the total load of that block.
m. Allow for manually adding or shedding loads.

22. Synchronizer / Load-Share Controller Screen

a. Screen shall include a representative image icon of the actual controller and dynamically updated parameters that are available from the controller such as metering status (voltages, currents, power measurements) and synchronization status (frequencies, voltages, synchroscope).

23. Automated email and text messages shall be transmitted when shutdowns occur and shall include time and date of alarm.
24. Based on either the number operations or the time since the last maintenance, suggest maintenance period for generator (run hours), controlled circuit breaker (number of operations), and transfer switches (number of transfers).
25. Status and Alarm Screen:

    a. Visual alarm status indicator and alarm horn with silence and acknowledge push button.
    b. Status, Light Only:

        1) "SYSTEM NOT IN AUTO" (red).
        2) Running Status: Display engine generator number and running-status light (green).
        3) Load-demand mode (green).
        4) Priority Load Status: Display load number with "LOAD ADD" (green) and "LOAD SHED" (red).
        5) System test (green).
        6) Remote system start (red).
        7) Monitoring of Each Transfer Switch:

            a) Normal source available for each (green).
            b) Connected to normal (green).
            c) Generator source available (green).
            d) Connected to generator source (green).

    c. Status Light and Alarm:

        1) Isolated paralleling bus under frequency (red).
        2) Isolated paralleling bus over frequency (red).
        3) Auxiliary power failure (red).
        4) Emergency start signal power failure (red).
        5) Load-Shed Level Status: Displays load number and red load-shed, status light.
        6) Generator Alarm Status: Displays generator number and red "Check Generator" status light.
        7) Controller malfunction (red).
        8) Check station battery (red).
        9) Isolated paralleling bus overload (red).
        10) System not in auto (red).
        11) Main tank, low fuel (amber)
        12) Main tank, high fuel (amber).
        13) Main tank, fuel leak (red).

I. Remote Monitoring: Replicate human-machine interface monitoring functions at generator control room workstation via communication bus (Ethernet).

J. Generator Digital Synchronizer and Load Controller

1. Each generator control section shall be provided with a digital synchronizer and

load/var controller.

2. The digital synchronizer and load controller designed for use on three-phase AC generators and mounted in the switchgear. The controls shall combine a synchronizer (with voltage matching capability), load sensor, load control, dead bus closing system interlock, VAR, power factor and process control. The load sharing network and VAR sharing network shall be redundant and completely integrated in the switchgear with network status monitoring and diagnostics available via switchgear operator terminal screens. The controls shall sense true RMS power and provide soft loading and unloading functions on the main bus.
3. The following functions shall be provided:

    a. Reverse Power Protection (Device 32R)
    b. Generator Voltage Monitoring and Frequency Monitoring
    c. Generator controls shall monitor voltage and frequency to ensure the generator is not connected to the bus until frequency is at least 59 Hertz and 90% rated voltage.
    d. Automatic Synchronizer:

    1) The synchronizer shall include a differential voltage detector, differential frequency detector and differential phase detector. Analog voltage bias signal shall be provided for voltage matching and an analog speed bias signal shall be provided for frequency matching and phase angle control. Synchronizer shall issue a breaker close signal when frequency, phase and voltage conditions are met.
    2) The differential voltage detector shall compare the voltage of the oncoming generator to the paralleling bus. If the voltage is not within the factory set difference of plus or minus 5% (adjustable from 0 to plus or minus 10%), the voltage detector shall inhibit the circuit breaker from closing. When the oncoming generator voltage is within the preset acceptable limit, the inhibit shall be removed.
    3) The differential frequency detector shall compare the frequency of the oncoming engine generator set to the paralleling bus. If the frequency is not within the preset acceptable difference of plus or minus 0.5 Hz (adjustable from 0 to plus or minus 0.5 Hz), the frequency detector shall inhibit the circuit breaker from closing. When the oncoming engine generator frequency is within the acceptable limit, the inhibit shall be removed.
    4) The differential phase detector shall compare the phase angle of the oncoming engine generator set to the paralleling bus. If the phase angle is not within the preset acceptable difference of plus or minus 0.05 Hz (adjustable from plus/minus 0.02 to 0.25 Hz), the phase detector shall inhibit the circuit breaker from closing. When the oncoming engine generator phase angle is within the acceptable limit, the inhibit shall be removed.

    e. Multiple Circuit Interlock (Dead Bus Arbitration:

    1) Generator controls shall provide for first-up, first-on operation of the generator set. This device shall positively prevent more than one set

from being simultaneously connected to a dead bus. Upon initiation of the connection of the first set to the bus, this circuit shall shift the control of the remaining sets to automatic or manual synchronizing at the operator's discretion.

K. Generator Control Selector Switches and Pushbuttons

1. Five Position Engine Control Selector Switch:

a. Lockout/Reset - When placed in this position, the engine shall not be capable of starting and/or running from the master paralleling controller. If the engine was shut down due to the operation of a protective device, the shut down shall be reset when the switch is moved to this position. If the engine is running when the switch is moved to this position, it shall immediately shut down, the circuit breaker shall be opened and the and the generator locked out.
b. Off/Cooldown - When placed in this position, the generator shall be soft unloaded from the bus (when possible) and the engine start signal shall be removed after a defined cool-down period.
c. Automatic - When placed in this position, the engine control shall be in readiness for fully automatic operation upon receipt of a start signal.
d. Test Off-Line - When placed in this position, the engine shall start and run as if a start signal were received except the circuit breaker shall not be closed and it shall not be connected to the bus. If a start signal is received, normal automatic functions shall resume. When returned to the Automatic position, the engine shall shut down.
e. Test On-Line - When placed in this position, the engine shall start, run, and connect to the bus. When returned to the Automatic position the circuit breaker shall open, provided no automatic start signal is present, and the engine shall run for its cool-down period before shutting down.

2. Four Position Synchronizing Mode Selector Switch:

a. Permissive - In this position the governor controls are deactivated. However, the synchronizer shall operate as a passive synch check relay and signal the closing of the generator breaker when both sources are in phase.
b. Check - In this position the synchronizer is fully operational except it cannot close the generator breaker. The phase-lock feature holds the generator output in synchronism with the bus.
c. Off - In this position the synchronizer is turned off to allow for manual paralleling at the Master Cubicle.
d. Run - In this position the synchronizer is in the fully operational, automatic mode.

3. Emergency Stop Pushbutton.

L. System Annunciation (Hard-wired Status Tiles - LED).

1. Lamp Test (Pushbutton)
2. Gen # Running (Green)
3. Gen # Online (Red)
4. Gen # Locked Out (Red)
5. Pri # Load Shed Active (Amber)
6. Pri # Load Shed Bypassed (Amber)
7. System Test (Amber)
8. Emergency Mode (Amber)
9. I/O Comm Failure (Red)
10. System PLC Diagnostic Fault (Amber)
11. Load Demand Mode Active (Amber)
12. Load Demand Start TD Active (Amber)
13. Load Demand Stop TD Active (Amber)
14. Bus Under Frequency (Red)
15. Bus Over Frequency (Red)
16. Bus Under Voltage (Red)
17. Bus Over Voltage (Red)
18. Bus Optimization Mode Active (Amber)
19. Next Load Exceeds Headroom (Amber)
20. Bus Loaded To Capacity (Amber)
21. Bus Overload (Red)
22. Station Battery Charger Failure (Amber)
23. PLC 1 Stopped (Red)
24. PLC 2 Stopped (Red)
25. Control Voltage Failure (Red)
26. DC Converter Failure (Red)

M. Generator Annunciation (PLC Inputs and HMI Screen Display), One set provided for each generator.

1. Parallel CB Open (Green)
2. Parallel CB Closed (Red)
3. Parallel CB Lockout (Red)
4. Parallel CB Fail To Close (Red)
5. Failure To Sync (Red)
6. Parallel CB Not Connected (Red)
7. Parallel CB Fail To Open (Red)
8. Ground Fault Alarm (Red)
9. Over Crank Shutdown (Red)
10. Over Speed Shutdown (Red)
11. Reverse Power Shutdown (Red)
12. Low Oil Pressure Shutdown (Red)
13. High Water Temp Shutdown (Red)
14. Auto Start (Green)
15. ECS Reset Required (Red)
16. Engine Control Not In Auto (Red)
17. Low Oil Pressure Alarm (Amber)
18. High Water Temp Alarm (Amber)
19. Engine Running (Green)

20. PLC Stopped (Red)
21. Control Voltage Failure (Red)
22. Controls Not In Auto (Red)
23. Local/Remote Emergency Stop (Red)
24. Low Water Level Alarm (Amber)
25. Low Water Temp Alarm (Amber)
26. Powerquest Override (Amber)
27. Day Tank Low Fuel (Amber)
28. Day Tank High Fuel (Amber)
29. Day Tank Rupture Basin (Amber)
30. Battery Charger Failure (Red)
31. High Battery Voltage (Amber)
32. Low Battery Voltage (Amber)
33. Gen Common Shutdown (Red)
34. Gen Common Alarm (Amber)
35. DC Converter Failure (Red)
36. Synchronizer Self-Test Failed (Red)

2.5 SWITCHGEAR ENCLOSURE

A. Indoor Enclosure: Steel.

B. Switchgear Enclosures Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.6 COMMUNICATIONS

A. Medium voltage paralleling metal clad switchgear equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet.

B. Ethernet Connectivity: Gear Supplier shall provide their standard communication network to comply with the performance of this sub-paragraph.
   1. Install a multipoint, Modbus TCP communications network, by suppling manufacturer standard within the switchgear to interconnect all breaker trip units, and metering devices equipped with communications.
   2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.
   3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-T LAN.
   4. All serial communications devices within the equipment shall be addressed at the factory and tested.
   5. The supplier has option to provide Modbus TCP/IP over Ethernet direct to each

breaker in lieu of serial Modbus and gateways.

6. All serial communications devices within the equipment shall be addressed at the factory and tested.
7. Compliance with ASHRAE 135: Controllers shall support Modbus TCP/IP over Ethernet communications and shall be able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.7 SWITCHGEAR CONSTRUCTION

A. Deadfront, metal-clad, drawout, switchgear assembly of vertical sections, each with vacuum circuit breakers. Provide additional vertical sections to house accessories related to the switchgear functions.

1. Front and rear access switchgear.
2. Front and rear vertical section covers with full-length hinges. The front and rear cover must be a flanged door with latching hardware. The latching hardware shall be lockable by a padlock suitable for lockout protection.
3. Infrared Window: Each breaker compartment shall contain round window ports. The ports shall be 4”. The window ports quantity and locations for each breaker must be positioned to provide optimal viewing with external infrared camera.

B. Bus: Tin-plated or Silver-plated copper.

1. Phase Bus: 2000A, epoxy insulated bus. All bus joints shall be plated, bolted and insulated with easily installed boots.
2. Ground Bus: Sized to carry the rated short-time withstand current, extended full length of the switchgear assembly, and connected to the metal enclosures of each vertical section.
3. Grounding Stud Ball: Each rear cabinet shall include a grounding stud ball connection for safety grounding. Provide hot-stick removable insulated ball cover.

C. Circuit Breaker Compartments: Include a racking mechanism, circuit breaker operated automatic shutters covering the high-voltage bus connections, safety interlocks, and an electrical racking motor and accessories for remote racking of the circuit breaker.

1. Draw out Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

    a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
    b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of the breaker. Disconnecting devices shall be gold plated, and engagement shall be maintained in the "connected" and "test" positions.
4. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.
5. All space for circuit breaker shall be fully bussed and dressed to receive future breakers.
6. Complete operation of the circuit breaker and trip unit must be accessible without opening the circuit breaker door.
7. Padlocking provisions shall permit locking the circuit breaker in either the “test” or “disconnected” position.
8. Safety shutters shall be provided to cover the circuit breaker primary line and load disconnects.
9. Each circuit breaker compartment shall contain a rejection feature that allows only the insertion of an intended circuit breaker.
10. All circuit breakers of like size and ratings shall be completely interchangeable.
11. Each compartment shall contain Shutter-less Wall/Barriers that provides a physical touch-safe barrier between the busbars and operator.

D. Auxiliary Vertical Sections and Compartments:

1. Paralleling Master Controller: Provide vertical section to house HMI system and generator controls.
2. Redundant Paralleling Master Controller: Provide vertical section to house HMI system.
3. Owner's Metering: A vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.

E. Circuit Breakers: Horizontally mounted, draw out, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

1. Electrically Operated: 125V dc close and trip. Powered from an external power

source.

F. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation.

1. One of each size handling device to remove the circuit breaker from metal-clad switchgear and to move the breaker about on the floor. Devices include but are not limited to a floor operated portable lifting crane, breaker lifting yoke, rail extensions and dockable dolly.
2. Test cabinet with accessories to connect to the secondary contacts on an electrically operated removable element, permitting operation and testing of the removable element when it is removed from the housing.

G. Remote-Breaker Racking:

1. Provide two (2) complete automated remote racking systems for 15KV circuit breakers.
2. Remote racking device provides a means of remotely inserting or removing draw out circuit breaker in the switchgear.

    a. A remote racking device shall be supplied to allow qualified personnel to rack breakers into Connect, Test and Disconnect positions from up to 25 feet away from the breaker and outside the arc flash hazard boundary.
    b. The remote racking device shall support utilization on any Frame Size.
    c. The remote racking device shall be portable and weigh less than 30 pounds (excluding cables and remote-control panel).
    d. The remote racking device shall have integral torque overload sensing to prevent damage to the breaker racking mechanism.
    e. The remote racking device shall allow breaker to be racked to any position (disconnect, test, connect) regardless of the starting position of the breaker and without the need for user input as to the starting position.
    f. The 120v remote breaker racking device shall be attached to the factory mounted switchgear brackets (field retrofit capable) and secured by locking pins. No modification of the gear or circuit breakers shall be required for installation or operation.

H. Remote Breaker Operation

1. The Master Control Cabinet shall include an HMI panel with virtual control switch for each feeder breaker. Include a verification step in “Open” and “Close” sequence to avoid nuisance operations. The cabinet shall include one hand selector switch for each generator breaker.

I. Capacities and Characteristics:

1. Comply with IEEE C37.06.
2. Switchgear Assembly:

a. System Voltage: 13.2KV, Three Phase.
b. Rated Maximum Design Voltage and BIL (Dielectric Test): 15 kV and 95 kV.
c. Rated Continuous Current: 2000 A.
d. Rated Short-Circuit Current and Short-Time Current: 40 kA rms.
e. Power Frequency Withstand: 36KV.
f. Momentary Current Ratings: Equal to the circuit breaker close and latch rating.

3. Circuit Breakers: Same capacities and characteristics as the switchgear assembly, and as follows:

a. Rated Continuous Current and Load Switching Current:
1) Main and Tie: 2000 A.
2) Feeder: 1200A.
b. Rated Closing and Latching Current: 104 kA, peak.
c. Rated Interrupting Time: 50 ms.

2.8 SURGE ARRESTERS

A. Comply with IEEE C62.11, station class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

2.9 INSTRUMENTS

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

B. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Three-Phase Apparent Power: Plus or minus 2 percent.
g. Power Factor: Plus or minus 2 percent.
h. Frequency: Plus or minus 0.5 percent.
i. Integrated Demand, with Demand Interval Selectable from 5 to 60

Minutes: Plus or minus 2 percent.

j. Energy: Watts, Watt Demand, Watt-hours, VARs, VAR Demand, VAR-Hour, VA, VA Demand and VA-Hour.

k. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Event Waveform Capture shall record the voltage and current waveforms for each event exceeding settable thresholds. stored values unaffected by power outages for up to 72 hours.
4. Communications module suitable for remote monitoring of meter quantities and functions. Information to be communicated in Modbus TCP/IP over Ethernet. Connections to HMI / OIT, SCADA, BMS and downloadable to USB Drive.
5. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
6. Provide metering for each circuit breaker installed.

C. Analog Instruments: Rectangular, 4-1/2 inch (115 mm) square, 1 percent accuracy, semi flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Cover an expanded scale range of normal plus 10 percent.
2. Selector Switch: Rotary type with off position to provide readings.

2.10 PROTECTIVE RELAYS

A. Multifunctional, solid-state microprocessor-based relay systems, complying with IEEE C37.90.

B. Relay Mounting:

1. Each relay shall be mounted in a detachable or draw out case with a two-stage quick-release operation.
2. Removal of the relay from the case shall disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.
3. When the relay is inserted into the case, control power connections shall be made before the trip circuits are activated.
4. Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.
5. Provide required CT and PT wiring to each digital protective relay.
6. Provide fiber optic arc flash detection sensors, wiring and connections as required for arc flash detection coverage of each corresponding side of the switchgear. Set for flash and current rate of rise.
7. Provide maintenance setting switch on protective relay to reduce arc flash hazard when the switch is in the maintenance mode position.
8. Manufacturer must provide initial protection relay settings to complete factory testing.
9. The manufacturer field technician onsite shall complete relay setting adjustments required to meet the field quality control startup and commissioning.

C. Equip each relay system with a communications module to transmit data.

1. Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
2. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

D. Overcurrent and Ground-Fault Protective Relays:

1. IEEE C37.2 and ANSI device functions as specified for each type of load. The basis of design manufacturer is SEL.
2. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.
3. Primary Current-Transformer Ratings: Programmable from 5 to 5000 A.
4. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
5. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and shall be deactivated after approximately eight cycles.
6. Contacts:

    a. Minimum of Two Form-A contacts.
    b. Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:
        1) One contact assigned ANSI 51 phase and ANSI 51 ground, and the other contact assigned ANSI 50 phase and ANSI 50 ground.
        2) One contact assigned ANSI 51/50 phase, and the other contact assigned 51/50 ground.

7. Alphanumeric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current-causing trip.
    e. Phase or ground indication.
    f. Peak current demand for each phase and ground since last reset.
    g. Current-transformer primary rating.
    h. Programmed phase and ground set points.

8. Relay alarm and trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip on detection of an overcurrent or fault condition based on programmed settings. A "protection off" alarm shall be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this

alarm relay shall be de-energized, providing a fail-safe protection off alarm.

E. Switchgear shall include following type, rating and protection relay: SEL Relays identified as Base-Line.

1. Feeder Circuit Breaker: SEL 751A - ANSI 50/51P, 50/51G, 50 PAF, 62 and 86.
2. Tie Circuit Breaker: SEL 751A - ANSI 50/51P, 50/51G, 62 and 86.
3. Generator Circuit Breaker: SEL 700G - ANSI 25, 27, 32, 40, 46, 50P, 50/51G, 51V, 59, 81 O/U, 87G and 86.

F. Arc Flash protection for feeder breakers shall be provided by the protection relay. System shall include one style or a combination of both fiber optic cable and fiber optic point sensors. Trip identification shall include both light flash and current rate of rise.

G. Indicating Lights: To indicate circuit breaker is open or closed.

2.11 CONTROL POWER SUPPLY

A. Dedicated 125 V dc battery system. Dual redundant systems.

B. Manufacturers:
1. EnerSys
2. Saft
3. SBS
4. SENS
5. Approved Equal

C. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity at 77 deg F (25 deg C) with electrolyte at normal level and minimum ambient temperature of 55 deg F (13 deg C). Cycle battery before shipment to guarantee rated capacity on installation. Arrange to operate ungrounded. Battery system capacity must be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.

1. Battery system must be fully redundant with separate battery racks and chargers. Each system sized for 100% operation.

a. Size system for two complete trip charge operations for each breaker. Once at loss of Utility power and once after eight hours of maintained steady state operation.

2. Provide battery sizing and load profile system report.

D. Battery: Ni-Cd system is the basis of design. Li-ion system is an acceptable alternative.

1. Batteries, with system disconnect and overcurrent protective device.
2. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals

for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.

3. Accessories: Set of battery cell numerals.
4. Charger: Solid State Switch Mode equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit must automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

    a. DC ammeter.
    b. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
    c. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
    d. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
    e. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation must be automatic until manually reset.
    f. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3 Hz variation in frequency. Automatic charger operation must resume after loss of ac power supply for interval.
    g. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device must regulate charging current but must not disconnect charger from either battery or ac supply.
    h. Charger's Audible Noise: Less than 26 dB.

E. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

F. Battery Cell Monitoring System with normal/trouble/alarm communication to SCADA and BMS systems.

G. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

1. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
2. Conductors: Sized according to NFPA 70 for duty required.

2.12 IDENTIFICATION, WARNING LABELS AND SIGNS

A. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for OSHA 29 CFR 1910.269.

1. Warning signs must be baked enamel signs.
2. Equipment Identification Labels: Laminated acrylic or melamine plastic signs.

B. Compartment Nameplates: Engraved, metal nameplate for each compartment, mounted with corrosion-resistant screws.

C. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Color: Contrasting with factory-finish background.

2.13 SOURCE QUALITY CONTROL

A. Perform production tests on each circuit breaker housing for this Project, complying with IEEE C37.09.

1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
2. Conduct an alignment test with master circuit breaker to verify all interfaces.
3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
4. Perform the control wiring dielectric test at 1500 V for one minute.
5. Perform the dielectric test on primary and secondary circuits.

B. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE C37.09.

1. Perform mechanical operation tests to ensure proper functioning of the switch.
2. Conduct an alignment test with master cell to verify all interfaces and interchangeability.
3. Verify the contact gap. Perform terminal-to-terminal resistance test.
4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.
5. Perform the control wiring dielectric test at 1500 V for one minute.
6. Set the contact gap.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Provide factory certified technician(s) to complete tests, adjustments and inspections. See above, Part 1 - 1.08 Warranty and Part 1 – 1.09- Start-Up.

3.2 SYSTEM FUNCTION COMMISSIONING TESTS

A. Manufacturer's Field Service: Provide factory-authorized service technician(s) to provide startup and commissioning of paralleling switchgear.

1. Services to include service technician(s) being on site as each circuit breaker is energized to test programing and functionality.
2. Provide documentation confirming results of testing.
3. Provide field programming and relay setting adjustments required to complete field quality control, startup and commissioning.

B. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. The generator functional tests shall be completed during the same time period.
2. Provide test parameters and submit to Owner/Project Representative minimum of eight (8) weeks prior to testing for review and approval.
3. Perform approved submittal tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
4. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
5. Verify the correct operation of sensing devices, alarms, and indicating devices.
6. Complete system function tests for each mode in Section 261327.11 “Sequence of Operation”.

    a. Including a full power loss test.
    b. Tests to model the loss of generator units during loss of power event.
    c. Tests to model generator units not starting when called to service and loss of generator during service.

C. Provide complete startup and commissioning test report for switchgear.

3.3 SIMULATOR TEST

A. Prior to the factory witness test, the medium voltage paralleling switchgear manufacturer shall provide a system simulator for full sequence testing of the Master PLC.

3.4 FACTORY WITNESS TEST

A. The medium voltage paralleling switchgear manufacturer shall include in the proposal a factory witness test that provides testing of the switchgear lineup, including failure recovery operations. The manufacturer shall provide the ability to simulate source loss, circuit breaker failure and undervoltage and overload events. Factory testing schedule shall be provided minimum of four weeks prior to testing for coordination of travel accommodations. The proposal shall include Owner travel expenses:

1. Include costs associated with Owner travel expense to witness factory testing. Total value attributed to travel expense shall be clearly indicated.
2. Expenses shall include roundtrip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.
4. Include travel expenses for two Owner Representatives, with origin of Indianapolis, IN.

END OF SECTION 261327.1

SECTION 261327 - MEDIUM-VOLTAGE, PARALLELING METAL-CLAD SWITCHGEAR - INSTALL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Installation of Medium Voltage Switchboards

B. Related Requirements:
   1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   2. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in switchgear.

1.2 DEFINITIONS

A. NETA ATS: International Electrical Testing Association, Acceptance Testing Specification.

1.3 SUBMITTALS

A. Product Data: For each type of product.

   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Field Connection Wiring Diagrams: Power, signal, and control wiring.
   2. Dimensioned plans and elevations showing major components and features.

      a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
   3. One-line diagram.
   4. List of materials.
   5. Nameplate legends.

C. Field quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of switchgear to allow movement into designated space.

C. Store switchgear components protected from weather and so condensation does not form on or in units. Provide temporary heating in accordance with manufacturer's instructions.

D. Handle switchgear components in accordance with manufacturer's instructions. Use factory-installed lifting provisions.

1.5 WARRANTY

A. Installer’s Warranty Period: Provide a warranty for one year from the date of substantial completion. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include coverage for labor, material and expense costs to correct all defects.

E. Warranty requirements specified in the Owner’s contract documents which are more stringent than those listed in this specification shall override these requirements.

PART 2 - PRODUCTS

2.1 Provide Gear Maintenance Cabinet: Identified and compartmented steel cabinet with lockable hinged doors. Sized for breaker remote racking out devices, breaker test devices, flexible cord sets and miscellaneous gear equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.

1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.
2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and shop drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
5. Unload switchgear, observing packing label warnings and handling instructions.
6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle switchgear in accordance with manufacturer's recommendations, avoid damage to the enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
2. Protect switchgear compartments against the entrance of dust, rain, and snow.
3. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
4. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
5. Do not damage structure when handling switchgear.

C. Storage:

1. Store switchgear in a location that is clean and protected from weather. Protect switchgear from dirt, water, contamination, and physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
2. Store switchgear with compartment doors closed.
3. Regularly inspect switchgear while in storage and maintain documentation of storage conditions, noting discrepancies or adverse conditions.

D. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

E. Pre-Installation Checks:

1. Verify removal of shipping bracing after placement.

F. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 ohms ohms at switchgear location.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SWITCHGEAR

A. Comply with the provisions of IEEE ANSI C37.20.2 subclause titled "Guide for Handling, Storage, and Installation."

B. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). See structural sheets for equipment base details.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Comply with requirements for vibration isolation devices specified in Section 260529 "Hangers and Supports for Electrical Systems."

C. Switchgear must be installed level and plumb. Switchgear must tilt less than 1.5 degrees while energized.

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's written instructions and NFPA 70.

E. Comply with NECA 430.

3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable not smaller than No. 4/0 AWG for grounding cabling to grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

D. Complete switchgear grounding and lightning arrester connections prior to making other electrical connections.

E. Terminate medium-voltage cables in accordance with Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Construction Manager Project Representative.

B. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

C. Medium-Voltage Switchgear Assembly Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
b. Verify that current and voltage transformer ratios correspond to Drawings.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Inspect insulators for evidence of physical damage or contaminated surfaces.
g. Verify correct barrier and shutter installation and operation.
h. Exercise active components.
i. Inspect mechanical indicating devices for correct operation.
j. Verify that filters are in place and vents are clear.
k. Perform visual and mechanical inspection of instrument transformers in accordance with "Instrument Transformer Field Tests" Paragraph.
l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.

e. Control Power Transformers:

1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at devices.
3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

f. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

g. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Perform system function tests in accordance with "System Function Tests" Article.
i. Verify operation of space heaters.
j. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism must be in accordance with manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values must not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the trip and close coils must comply with manufacturer's published data. In the absence of the manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer's published data.
e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.

f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values must comply with manufacturer's published data.
g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.
h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
i. Verify operation of heaters.

E. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.
c. Verify correct connection of transformers with system requirements.
d. Verify that adequate clearances exist between primary and secondary circuit wiring.
e. Verify the unit is clean.
f. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
g. Verify that required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of

insulation resistance less than manufacturer's written recommendations or NETA ATS, Table 100.5.

c. Perform a polarity test of each current transformer in accordance with IEEE ANSI C57.13.1. Polarity results must agree with transformer markings.

d. Perform an excitation test on transformers used for relaying applications in accordance with IEEE ANSI C57.13.1. Excitation results must match the curve supplied by the manufacturer or be in accordance with IEEE ANSI C57.13.1.

e. Measure current circuit burdens at transformer terminals in accordance with IEEE ANSI C57.13.1. Measured burdens must be compared with and must match instrument transformer ratings.

f. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages must be in accordance with Table 100.5.

g. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages must be in accordance with Table 100.9.

h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.

i. Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

3. Electrical Tests of Voltage Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages must be applied for one minute in accordance with Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.

c. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable. Polarity results must agree with transformer markings.

d. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared with and must match instrument transformer ratings.

e. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.

f. Verify that voltage transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. Test results must indicate that the circuits are grounded at only one point.

F. Ground Resistance Test:

1. Visual and Mechanical Inspection:

a. Verify ground system complies with Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections must be free of corrosion.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
d. Inspect anchorage.

2. Electrical Tests:

a. Perform fall-of-potential or alternative test in accordance with IEEE Std 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground must be no more than 5 ohms.
b. Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohm. Compare equipment nameplate data with Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using a low resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

G. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

    a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
    c. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
    d. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
    e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results must confirm the integrity of the secondary circuits of current and voltage transformers.

H. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

    a. Verify that equipment nameplate data complies with Contract Documents.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding, and clearances.
    d. Verify the arresters are clean.
    e. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
    f. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

2. Electrical Test:

    a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.
    b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
    c. Test grounding connections. Resistance between the arrester ground terminal and the ground system must be less than 0.5 ohm.

I. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

    a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
    b. Verify operation of light-emitting diodes, display, and targets.
    c. Record passwords for each access level.
    d. Clean the front panel and remove foreign material from the case.

e. Check tightness of connections.
f. Verify that the frame is grounded in accordance with manufacturer's instructions.
g. Set the relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.
b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) Sync Check Relay:

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

4) Undervoltage Relay:

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on the timing curve for inverse time relays.

5) Directional Power Relay:

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.

c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on the timing curve for inverse time relays.

6) Current Balance Relay:

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

7) Negative Sequence Current Relay:

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on the I-two-squared-t curve.

8) Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.

9) Time Overcurrent:

a) Determine minimum pickup.
b) Determine time delay at two points on the time current curve.

10) Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

11) Directional Overcurrent Relay:

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine overcurrent unit pickup.
d) Determine overcurrent unit time delay at two points on the time current curve.

d. Control Verification:

1) Functional Tests:

a) Check operation of active digital inputs.
b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.

c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

J. DC System Vented NiCd Batteries Field Test:

1. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify equipment nameplate data complies with Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify electrolyte level. Measure pilot-cell electrolyte temperature, and correct as recommended by manufacturer's maintenance procedures to bring the temperature and electrolyte level to within normal limits.
h. Verify the units are clean.
i. Inspect spill containment installation.
j. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and that alarms comply with system manufacturer's recommendations.
c. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published data.
d. Measure intercell connection resistances.
e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
f. Perform a load test in accordance with manufacturer's published data or IEEE Std 1106. Replace units that fail to pass the test.
g. Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive-to-ground must be equal in magnitude to the voltage measured from negative to ground.

K. Nonconforming Work:

1. Switchgear will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

L. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.6 SYSTEM FUNCTION TESTS

A. System function tests must prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, if requested by Owner, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each switchgear. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

    a. Adjust switchgear taps.
    b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.
4. Report:

    a. Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove covers prior to the inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 86 deg F.

3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used and lists the results as follows:

    a. Description of equipment to be tested.
    b. Discrepancies.
    c. Temperature difference between the area of concern and the reference area.
    d. Probable cause of temperature difference.
    e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
    f. Identify load conditions at time of inspection.
    g. Provide photographs and thermograms of the deficient area.

4. Act on inspection results in accordance with the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION 261326.1

SECTION 261327.11 - SEQUENCE OF OPERATION

PART 1 - GENERAL

A. RELATED DOCUMENTS

1. See drawing sheets EP-701, EP-703, EP-716 and EP-505

2. Section 261327 – Medium Voltage, Paralleling Metal-Clad Switchgear - Purchase.

3. Section 263213.13 – Diesel-Engine-Driven Generator Sets – Purchase.

B. EXECUTIVE SUMMARY

1. In the event one Utility service feeder is lost, the Main Service Switchgear (MSS) controller will automatically switch to feed the entire switchgear from the second Utility service feeder. The MSS controller will open the main breaker on the lost Utility side and close the tie breaker. The SCADA communications between the MSS and the Paralleling Switchgear (PS) will signal the generators to start.
2. In the event of both Utility service feeders being lost, the SCADA communications will start the generators.
    a. MSS - Both Main Breakers will open to isolate the switchgear from the Utility outage. Switchgear controls will continue to monitor the Utility side of the main breaker for a return to normal power.
    b. MSS - Tie Breaker will remain open.
    c. SCADA system to initiate the generator start includes:
        - CUP - MSS
        - CUP – Medium Voltage Automatic Transfer Switches
        - CUP – 480V Automatic Transfer Switches (Life Safety, Critical and Elevators)
        - AAHC – 480V Automatic Transfer Switches (Life Safety, Critical and Elevators)
        - SSB – 480V Automatic Transfer Switches (Life Safety, Critical and Elevators)
        - Plaza Garage – 480V Automatic Transfer Switches (Life Safety, Critical and Elevators)
    d. PS – On loss of power signal All generators shall start.
    e. PS – The tie breaker is in the open position during startup, creating a side A and side B emergency bus.
    f. PS-Side A - The first generator to reach voltage and frequency will be selected and breaker closed to feed the PS Side A emergency bus. This will happen in less than 10 seconds.
    g. PS-Side B - The first generator to reach voltage and frequency will be selected and breaker closed to feed the PS Side B emergency bus. This will happen in less than 10 seconds.
    h. PS (Side A and Side B) - The second generator to parallels the emergency bus voltage and frequency shall be selected and breaker closed to parallel feed the PS emergency bus. Same for Side A and Side B.

i. PS – On each emergency bus Side (A and B) the next generator to parallel the emergency bus voltage and frequency shall be selected and breaker closed to parallel feed the PS emergency bus. Same for Side A and Side B.
j. PS – With all generators paralleled to the emergency bus the PS controller shall sync between Side A and Side B to close the tie breaker and parallel both sides to one emergency bus.

3. PS – Feeder breakers connected to Essential and Life Safety switchgear shall be picked up first. This includes life safety panels in the CUP, AAHC, SSB and Plaza Garage. This will happen in less than 10 seconds.
4. See Spreadsheet – Generator Priority Loading for loading information.
5. In the event a generator fails to start or fails after running for a period of time, the controller shall evaluate the loads being served and use the priority list to load shed (Open Breakers) so the remaining generators are not overloaded.
6. The generators are controlled to sync with the Utility on return to normal power so no outage will be seen on return to normal power.
7. Once normal power is verified and the transition back to normal power is complete, each generator breaker will open and the generators shall start a cool down period before shutting off.

C. FUNCTIONAL SEQUENCE OF OPERATIONS

1. Automatic/Standby Mode

a. Paralleling medium-voltage switchgear, including controlled generators, controlled circuit breakers, other controlled devices, and transfer switches, shall be in the automatic position and ready to operate on loss of power or other designated initiation conditions.
b. Each single-generator monitoring and control system has not received a "start" signal from the PS controller.
c. Under normal conditions, the MSS two “Bus Main” breakers are closed powering their respective buses and the Tie circuit breaker is open. The PS is operating on station service battery power awaiting a signal to begin operation.
a. The PS automation is standing by to act in response to a utility/power loss failure.
b. Control power is source selectable. 125 Vdc battery system.
c. PS Master Generator HMI/OIT Control. Includes SCADA for breaker and metering information and redundant Master Controller.

2. Manual Mode: While in the manual mode, breakers shall be capable of being opened and closed using control switches located on the gear near the breaker or pushbuttons on the master HMI/OIT display. All time delays and interlocks shall be in effect.

3. The “Emergency” load bus sides A/B shall be generator power seeking and will connect as generators are available.

D. EMERGENCY MODE / GENERATOR MODE (BLACK START MODE)

1. Dual Utility Failure

a. Upon phase loss or loss of phase-to-phase voltage of either “MSS Main” (utility) source to between 80% and 100% of nominal, and after a time delay, adjustable

from 1 to 60 seconds to override momentary dips and outages, the transfer control system shall open the affected “MSS Main” circuit breaker and close the open “Bus Tie” circuit breaker to power the entire MSS lineup from the remaining main utility source.

b. MSS - Utility main breaker protective relaying senses utility voltage and frequency (relay function: 25,27/59,81O/U) out of tolerance at both utility sources.

    1) Initiate the open utility breakers signal upon utility loss within ½ cycle if it is within the breakers capability to meet AES Intertie Agreement Requirements.

c. PS – Shall initiate a generator start signal after receiving a power loss signal from the MSS or a controlled point (MV-ATS or ATS in the AAHC, CUP, SSB or PG).
d. Each single-generator monitoring and control system shall receive a start signal from the paralleling master control system that monitors loss of normal source availability.
e. On receiving a start signal, each single-generator monitoring and control system shall start engine generators and achieve rated voltage and frequency.
f. If engine generator fails to start, after expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
g. Inhibit Control: paralleling master control system receives loss of normal source availability sends inhibit signals.

    1) Building BMS serving HVAC loads that need to operate at a lower priority load by modifying the HVAC sequence of operation after detecting loss of normal source availability shall signal the DDC system for HVAC to change to the HVAC load-shed sequence of operation for the associated equipment.
    2) Building Elevator Controller serving elevator loads after detecting loss of normal source availability shall signal the associated elevator controllers that the elevators are connected to generator power and shall initiate the sequence of operation in the elevator control system to protect the elevators and to reduce elevator load demand.
    3) Inhibit Return to Normal Condition Sequence of Operation: Release of inhibit signal shall return individual equipment to normal power. Transfer switches shall verify when normal power is available at the transfer switch prior to transfer.
        a. Building Elevator transfer switches shall include a time delay inhibit and signal to elevator controller to return car and hold for transfer to normal power.
    4) Distribution circuit breakers in the paralleling medium-voltage switchgear, which are indicated in a priority-load schedule to transfer load by opening and closing the circuit breaker, receive an inhibit closing signal.

h. Black-Start Control: Prevent out-of-phase paralleling. After selecting the first generator to achieve 90 percent rated voltage and frequency, inhibit the connection of generator-controlled circuit breakers to the isolated paralleling bus, then close the circuit breaker connecting the first generator to the isolated paralleling bus.

    1) Redundant Control System: The Master Control System will include synchronous redundant PLCs, redundant I/O and ring network to allow failure of a single component or network connection with loss of automation. The generator control system (dead bus arbitration, synchronization, kw-sharing and load-sharing) shall

include redundant communications such that a loss of a switch or failure of a communication path shall not inhibit proper connection of a generator to the bus or proper kW or VAR sharing. Additionally, a droop backup function shall be included to allow dual failure of the generator communications network without loss of proper kW or VAR sharing.

i. Each single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling medium-voltage circuit breakers to the isolated paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.
j. Failure of an Engine Generator to Synchronize: If engine generator fails to synchronize, sound an alarm after a preset time delay, but continue to attempt to synchronize the engine generator until signaled to stop by manual operation.

2. DUAL UTILITY RESTORATION AND EXIT FROM EMERGENCY MODE.

a. When normal voltage has been restored after a time delay, adjustable from 10 to 600 seconds (to ensure the integrity of the source), the transfer control system shall verify the main utility sources are synchronized via a sync check relay before closing the open “Bus Main” circuit breakers.
b. Utility protective relaying senses utility voltage and frequency (relay function: 25,27/59,81O/U) within tolerance at both utility (AES A and AES B) sources.
c. MSS breaker (Bus Tie) is open.
d. MSS breaker (Bus A Main) is open.
e. MSS breaker (Bus B Main) is open.
f. Open Transition. Following an adjustable time delay (which can be abbreviated by the operator) to assure that the utility power sources are stable, the controller shall close the MSS breaker (Bus A Main).
g. Open Transition. Following an adjustable time delay (which can be abbreviated by the operator) to assure that the utility power sources are stable, the controller shall close MSS breaker (Bus B Main).
h. MSS breaker (Bus Tie) remains open.
i. PS master controller shall send signal to controlled devices the normal power is available.
j. MV-ATS: Begin process for closed transition transfer from emergency bus to normal bus. After restoration of voltage to the “MV-ATS Normal Side” bus and after a time delay, adjustable from 10 to 600 seconds, to assure that the normal power source is stable. The transfer control system shall sync and complete a closed transition, 100Msec overlap transfer.
k. ATS: AAHC, CUP, SSB and PG, ATS shall begin process for closed transition transfer from emergency bus to normal bus. After restoration of voltage to the “ATS Normal Side” bus and after a time delay, adjustable from 10 to 600 seconds, to assure that the normal power source is stable. The transfer control system shall sync and complete a closed transition, 100Msec overlap transfer.
l. PS: Master Control monitoring the emergency system shall confirm all loads transferred to normal bus and system operating on normal Utility power.
m. PS breaker (Bus Tie) shall open.
n. PS breaker(s) (FDR) shall return to normal settings.
o. PS: Controlled breakers for generators shall open. The generators shall start the cool down period.

p. The generators run for their programmed cool down period.
q. The system is now back in Automatic/Standby Mode.
r. If start signal is received during cool-down period, one engine generator on each side is reconnected to the emergency bus A and bus B sides, and system operation follows that of "loss of normal power."

3. SINGLE UTILITY AES A FAILURE

   a. MSS: Main A and Main B protective relaying senses utility voltage or frequency (relay function: 25,27/59,81O/U) out of tolerance at just utility AES A source.
   b. MSS breaker (Bus A Main) is opened.
   c. MSS breaker (Bus Tie) is closed.
   d. MSS breaker (Bus B Main) remains closed.

      1) Open the utility breakers upon utility loss within ½ cycle if it is within the breakers capability to meet AES Intertie Agreement Requirements.

   e. A run request is sent to PS master controller.
   f. The generators come up to voltage and frequency and hold for a set time period.
   g. Following an adjustable time delay (which can be abbreviated by the operator) to assure that the utility power sources are stable, the generators start their programmed cool down period.
   h. The system is now sourced from single utility AES B while in utility AES A failure mode.

4. RESTORATION OF UTILITY AES A WHILE IN SINGLE UTILITY AES A FAILURE MODE (UTILITY CLOSED TRANSITION).

   a. MSS: Main A protective relaying senses utility voltage and frequency (relay function: 25,27/59,81O/U) within tolerance at utility AES A source.
   b. Following an adjustable time delay (which can be abbreviated by the operator) to assure that the utility power source is stable).
   c. MSS breaker (Bus A Main) is closed.
   d. MSS breaker (Bus Tie) is opened.
   e. The system is now back in Automatic/Standby Mode.

5. SINGLE UTILITY AES B FAILURE

   a. MSS: Main A and Main B protective relaying senses utility voltage or frequency (relay function: 27/59,81O/U) out of tolerance at just utility AES B source.
   b. MSS breaker (Bus B Main) is opened.
   c. MSS breaker (Bus Tie) is closed.
   d. MSS breaker (Bus A Main) remains closed.

      1) Open the utility breakers upon utility loss within ½ cycle if it is within the breakers capability to meet AES Intertie Agreement Requirements.

   e. A run request is sent to PS master controller.
   f. The generators come up to voltage and frequency and hold for a set time period.

g. Following an adjustable time delay (which can be abbreviated by the operator) to assure that the utility power sources are stable, the generators start their programmed cool down period.
h. The system is now sourced from single utility AES A while in utility AES B failure mode.

5. RESTORATION OF UTILITY AES B WHILE IN SINGLE UTILITY AES B FAILURE MODE (UTILITY CLOSED TRANSITION).

a. MS: Main B protective relaying senses utility voltage and frequency (relay function: 25,27/59,81O/U) within tolerance at utility AES B source.
b. Following an adjustable time delay (which can be abbreviated by the operator) to assure that the utility power source is stable).
c. MSS breaker (Bus B Main) is closed.
d. MSS breaker (Bus Tie) is opened.
e. The system is now back in Automatic/Standby Mode.

E. TRANSFER TO GENERATOR MODE

1. Transfer to Generator Mode is a manual/deliberate transfer to Emergency/Generator Mode. The mode acts the same as Emergency.
2. Configure tests to comply with NFPA 110, Level 1 testing requirements for each generator. Automatically generate NFPA 110, Level 1 reports.
3. Single-generator test.
4. Multiple-generator test.
5. Start generators manually, by generator exerciser on user-defined schedule, or by selector switch located on Human Machine Interface touch screen controller.
6. Engine generator(s) start and achieve rated voltage and frequency.
7. Failure of Engine Generator to Start: After expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
8. Black-Start Control: Prevent out-of-phase paralleling. After selecting first generator to achieve 90 percent rated voltage and frequency, inhibit connection of generator-controlled circuit breakers to isolated paralleling bus, then close circuit breaker connecting first generator to isolated paralleling bus. Each single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to the isolated paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.
9. Failure of Engine Generator to Synchronize: If engine generator fails to synchronize, sound alarm after preset time delay, but continue to attempt to synchronize engine generator until signaled to stop by manual operation.
10. Manually select or automatically preselect whether test is a load or no-load test. If test is a load test, manually select or automatically preselect loads to be transferred according to schedule or by adjustable time delays.
11. In test mode, generators shall be soft loaded to normal grid.
12. If test is load-bank test, automatically operate load-bank breaker to connect load bank for testing generators based on number and configuration of generators.
13. After adjustable period of time the system, allow engine generators to optimize down to only the required number to be online to avoid wet stacking. Set stopping and starting

sequences through human-machine interface panel device and allow settings based on manual priorities or by engine run time.

14. On sensing available bus capacity diminished to set point, controller starts and closes engine generators to the isolated paralleling bus to accommodate load.
15. After system test is completed, transfer loads back to normal power with transfer switches. Shut down system using sequence in automatic mode.
16. If there is an outage during this mode of operation, automatically change to requirements specified in "Sequence of Operation for Loss of Normal Power Conditions" Paragraph, send load-shed signals to lower-priority loads until load is below generator capacity, signal any engine generator that is not currently operating to start, and cancel system test.
17. The generator test may be manually halted by activating a second momentary contact switch or from the HMI Dashboard. Activating the “Return to Utility” switch will zero the time delay, starting the “Sequence of Operation for Dual Utility Restoration and Exit from Emergency Mode” The generator start signal shall be removed.

18. ENTRY INTO GENERATOR TEST MODE

    a. Note: This mode can only be initiated when the system is in Automatic/Standby Mode – both MSS breakers (Bus A Main and Bus B Main) are closed and MSS breaker (Bus Tie) is open.
    b. PS: Master controller - the operator places the Utility Selector Switch for Transfer to Generator Mode into the “Generator Test” position.
    c. PS: Master controller - the operator places the Master Mode Selector Switch into the Transfer to Generator position.
    d. PS: Master controller - A run request is initiated.
    e. The generators start and run for a five-minute warm-up time.
    f. After completion of the warm-up time, the generators are synchronized and paralleled (relay function: 25) to the emergency bus A/B sides.
    g. PS breaker (Bus Tie) shall close.
    h. PS is operating all generators on one emergency bus.
    i. PS: Master Controller shall enable MV-ATS and ATS switches to make a controlled closed transition transfer, 100Msec overlap, to the emergency bus.
    j. The generators are loaded to meet the required testing.
    k. Utility protective relaying senses utility reversing power (relay function: 32) within tolerance at MSS breakers (Bus A Main and Bus B Main).

19. EXIT FROM GENERATOR TEST MODE.

    a. PS: Master controller - the operator removes the Master Mode Selector Switch from Transfer to Generator position and returns it to the Auto position.
    b. PS Master controller - following an adjustable time delay (which can be abbreviated by the operator), the generator plant is synchronized and paralleled to the utility normal sources.
    c. PS master controller shall send signal to controlled devices the normal power is available.
    d. MV-ATS: Begin process for closed transition transfer from emergency bus to normal bus. After restoration of voltage to the “MV-ATS Normal Side” bus and after a time delay, adjustable from 10 to 600 seconds, to assure that the normal power source is

stable. The transfer control system shall sync and complete a closed transition, 100Msec overlap transfer.

e. ATS: AAHC, CUP, SSB and PG, ATS shall begin process for closed transition transfer from emergency bus to normal bus. After restoration of voltage to the "ATS Normal Side" bus and after a time delay, adjustable from 10 to 600 seconds, to assure that the normal power source is stable. The transfer control system shall sync and complete a closed transition, 100Msec overlap transfer.
f. PS: Master Control monitoring the emergency system shall confirm all loads transferred to normal bus and system operating on normal Utility power.
g. PS breaker (Bus Tie) shall open.
h. PS breaker(s) (FDR) shall return to normal settings.
i. PS: Controlled breakers for generators shall open. The generators shall start the cool down period.
j. The generators run for their programmed cool down period.
k. The system is now back in Automatic/Standby Mode.

20. NO LOAD TEST MODE – ENTRY

a. PS: Master controller - the No Load Test Switch is placed in the ON position.
b. The generators are started.
c. PS All Generator Breakers remain open.
d. The system is now in No Load Test Mode.

21. NO LOAD TEST MODE – EXIT

a. PS: Master controller - the No Load Test Switch is placed in the OFF position.
b. The generators run for their programmed cool down period.
c. PS All Generator Breakers remain open.
d. The system is now back in Automatic/Standby Mode.

F. UTILITY FAIL TEST MODE

1. Entrance into Single Utility Fail Test Mode

a. PS: Master controller – Utility Fail Test screen, select Single Utility Fail Test, Switch is placed in the ON position. Select Utility Source to fail – AES A or AES B.
b. Voltage sensing at the selected MSS breaker Bus Main source protective relay is opened (relay function: 27), which simulates a loss of selected utility (AES A or AES B).
c. The system enters into a Single Utility Failure as described in the sequence above.

2. EXIT FROM SINGLE UTILITY FAIL TEST MODE

a. PS: Master controller - Utility Fail Test screen, the Single Utility Fail Test Switch is placed in the OFF position.
d. Voltage sensing at the selected MSS Bus Main utility protective relay is restored (relay function: 27), which returns to utility power.
c. The system exits from a Single Utility Failure as described in the sequence above.

3. ENTRANCE INTO DUAL UTILITY FAIL TEST MODE

a. PS: Master controller - Utility Fail Test screen, select Dual Utility Fail Test, Switch is placed in the ON position. Select Dual Utility Fail Test for both AES A and AES B. Confirm test verification request.
b. Voltage sensing at the selected MSS breakers Bus Main protective relays is opened (relay function: 27), which simulates a loss of utility AES A and AES B.
c. The system enters into a Dual Utility Failure as described in the sequence above.

4. EXIT FROM DUAL UTILITY FAIL TEST MODE

a. PS: Master controller - Utility Fail Test screen, the Dual Utility Fail Test Switch is placed in the OFF position.
b. Voltage sensing at the selected MSS Bus Main utility protective relays is restored (relay function: 27), which returns to utility power.
c. The system exits from a Dual Utility Failure as described in the sequence above.

G. PRIORITY LOAD AND LOAD SHED CONTROL

1. The PS Master Controls shall include a Load Shed Control function to control the loads served by the generators.

a. Programming shall be selectable and adjustable from the Human-Machine-Interface (HMI).
a. The signal to transfer loads to the engine generator source shall be accomplished by the PS master control.
b. Set priority blocks of load that indicate priority number and scheduled size of load from the Priority-Load Schedule. Set generator blocks of capacity that indicate the individual engine generators and their capacity.

2. The Load Shed Control shall control each of the distribution circuit breakers within the PS switchgear. Each electrically operated distribution circuit breaker shall be field selectable to be assigned to any of the available Load Shed Priority Levels. Additionally, Load Shed Control shall provide a 4 pole, 10A, 120VAC rated, form C set of contacts for each Load Shed Priority Level to allow for control of loads external to the switchgear if specified.

3. When generator has transferred Priority 1 emergency load, send signal to transfer loads that must be transferred within a specific time according to the Priority-Load Schedule.

4. When generator capacity is adequate to support next priority load, send signal to transfer next priority load to generator source until all priority loads have been transferred.

5. The following controls shall be provided for each level:

a. Shed Delay Timer, adjustable from 0 to 1024 seconds
b. Add Delay Timer, adjustable from 0 to 1024 seconds
c. Load Shed Override Selector (shed/auto/add)
d. Status indicators to show whether the Priority Level is Added or Shed

6. The Load Shed Controls shall have:

a. Load Shed Control Switch (On/Off)
b. User-settable Load Shed % (as a function of on-line generator capacity)
c. User-settable Load Add % (as a function of on-line generator capacity)
d. User-settable Bus Under frequency Set point
e. User-settable Bus Under frequency time delay
f. Bus Under frequency Reset Pushbutton
g. Bus Under frequency indicator

7. Load Sensitive Load Shed – Upon entrance into Single Utility Failure, Emergency/Generator Mode of operation or Single Utility Failure with Load Management, load shed shall shift to “Load Sensitive” mode. The system shall compare current generator and utility on-line capacity (in kW) to current load requirements. If surplus capacity is greater than the calculated Load Add set point, after the Load Add Time Delay the next Load Shed Priority will be added. This calculation will continue until all Sheddable Loads are added, or until surplus capacity is less than the calculated Load Add set point. If surplus capacity is less than the calculated Load Shed set point, after the Load Shed Time Delay the next Load Shed Priority will be shed. This calculation will continue until all Sheddable Loads are shed, or until surplus capacity is greater than the calculated Load Shed set point. The Load Shed Control, in its automatic shedding and adding of loads, shall not override any manual load shed/add operation.

8. Should the load bus frequency fall below the user selected bus under frequency set point for a period longer than the bus under frequency time delay, then all Priority Level loads shall be shed and load addition shall not resume until the operator has depressed the Bus Under frequency Reset button. The bus under frequency protection shall override any manual load add operation.

9. Loads shed can be reconnected to isolated paralleling bus only by manual reset at human-machine interface.

10. Load Shed Priority Levels: (#1 = Most important, #10 least important).

    a. Level 1 – PS breaker (FDR) – IUH-ESS-A. (ATS - Life Safety)
    b. Level 1 – PS breaker (FDR) – IUH-ESS-B. (ATS - Life Safety)
    c. Level 1 – PS breaker (FDR) – CUP-ESS. (ATS - Life Safety)
    d. Level 1 – PS breaker (FDR) – SSB-ESS. (ATS - Life Safety)
    e. Level 1 – PS breaker (FDR) – PG-ESS. (ATS - Life Safety)

    f. Level 2 – PS-MC-Inhibit – IUH-ESS-A. (ATS - Critical)
    g. Level 2 – PS-MC-Inhibit – IUH-ESS-B. (ATS - Critical)
    h. Level 2 – PS-MC-Inhibit – CUP-ESS. (ATS - Critical)
    i. Level 2 – PS-MC-Inhibit – SSB-ESS. (ATS - Critical)
    j. Level 2 – PS-MC-Inhibit – PG-ESS. (ATS - Critical)

    k. Level 3 – PS-MC-Inhibit – IUH-ESS-A. (ATS - Elevator)
    l. Level 3 – PS-MC-Inhibit – IUH-ESS-B. (ATS - Elevator)
    m. Level 3 – PS-MC-Inhibit – CUP-ESS. (ATS - Elevator)
    n. Level 3 – PS-MC-Inhibit – SSB-ESS. (ATS - Elevator)
    o. Level 3 – PS-MC-Inhibit – PG-ESS. (ATS - Elevator)

p. Level 4a – PS breaker (FDR) – MV-ATS-IUH-EQ-A.
q. Level 4b – PS breaker (FDR) – MV-ATS-CUP-MECH-A.
r. Level 4 – PS breaker (FDR) – MV-ATS-IUH-EQ-B.

s. Level 5 – PS breaker (FDR) – MV-ATS-CUP-MECH-B.
t. Level 6 – PS breaker (FDR) – MV-ATS-IUH-OS-A.
u. Level 7 – PS breaker (FDR) – MV-ATS-IUH-OS-B.

v. Level 8 – PS breaker (FDR) – MV-ATS-CUP-CH-A.
w. Level 8 – PS breaker (FDR) – MV-ATS-CUP-CH-B.
x. Level 10 – remaining PS (FDR) breakers. (Spares)
y. PS Breaker (FDR) – Load Bank. This breaker shall remain open during an emergency mode operation.

11. Load-Demand Sequence of Operation

a. With load-demand sequence of operation activated, controller continuously monitors total isolated paralleling bus load.
b. If isolated paralleling bus load is below preset limits and after a preset time delay, demand controller shuts down engine generators in predetermined order until minimum number of sets are operating. Set preset limits, predetermined order, and preset time delay, as well as choose manual operation, from human-machine interface.
c. On sensing available isolated paralleling bus capacity diminished to set point, controller starts and closes engine generators to isolated paralleling bus to accommodate load.

12. Dynamic Bus Optimization

a. Dynamic bus optimization will be enabled once the life safety loads have been energized. All other loads will be bus optimized; loads will not be added by quantity of generators connected to the bus.
b. Each load should be programmed with a load priority value (field adjustable, accessible via the OIT on the master section door). A load's priority value is a 3-digit number. The most significant digit refers to the load's block priority value (i.e. 201 => priority 2 load block, whereas 118 => priority 1 load block). The two lower significant digits refer to the load's sub-priority value, or load step priority (i.e. 201 => priority 2 block, step 1; and 118 => priority 1 block, step 18). Valid priority values are 1 – # while valid sub-priority values are 1 - 99. Therefore, valid three digit priority values are 101 - #99. Note: 3 digit priority values of 200, 300 and 400, etc. are not valid priority numbers. Because of the dynamic nature of the adjustable load priorities, all loads, even priority 1 need to have sub-priority step values.
c. Dynamic Load Bus Optimization is provided to add loads one at a time based on dynamically monitored kW readings (via Digital Meter mounted at each circuit breaker) up to 95% (adjustable via OIT) of the capacity of the on-line power. Note that the value read from the Digital Meter is the peak kW reading from the previous 24 hours. The minimum kW load value is set at 50kW, so if the received kW value is less than 50 the value will be overridden and 50kW will be used as the load value.
d. The Bus Optimization loading control will determine if there is enough room to add the next load by checking the dynamically monitored Load Value (via communication

to a Digital Meter mounted at each CB) assigned to the first sub-priority within the highest priority block and compare it to the excess generator bus capacity (also known as Headroom).

e. If it is determined that the load can be added without exceeding the Bus Optimization KW de-rating value, the load is signaled to add.
f. The real time kW output of the generator bus is constantly measured and the next sub-priority load is evaluated.
g. Loads are evaluated at a preset time interval defined via the OIT (Bus Opt Step Time).
h. When the bus has been loaded to a level such that the next load would exceed the de-rating value, the Next Load Exceeds Headroom light will activate and load adding will pause.
i. The system will continuously monitor the generator load and evaluate if the next load step can fit on the bus.
j. If building load decreases and the next load can fit (for the duration of the step time delay), the system will add it and continue the evaluation process until as many loads as possible are added to the bus.
k. Possible Failure Modes:

    1) Bus Overload: If at any time, the online load exceeds 105% of available rated capacity, the system will remove the last load that was added. If the online load does not decrease to less than 105% of rated capacity, loads will be shed one at a time, every second in reverse order until the overload is corrected. Life Safety loads will not be shed. The Bus Overload light will light to indicate that the bus is overloaded and will be automatically reset once the overload is corrected. In this event, the system will begin a 30 second overload stabilization delay time (fixed) before evaluating additional load to be added to the bus.
    2) Generator Failure: If a generator fails, it will be removed from the bus. If the load does not exceed the online capacity, no loads will shed.
    3) Bus Under frequency: In the event of a bus Under-frequency that lasts at least 3 seconds, all optimized loads will be shed. This is a latched condition that must be manually reset by the operator. Bus Op will be disabled while the condition is active. The “Bus Under Frequency” annunciator light will indicate this condition. The operator must acknowledge the alarm by pressing the Alarm Reset pushbutton (provided bus under frequency is still not active). After the operator acknowledges the alarm, bus optimization will start adding loads after a bus optimization start time delay and in the same manner as described previously for bus optimization in the preceding paragraphs.
    4) Loss of communication to a Digital Meter: the condition will be annunciated at the HMI. The last value read will be maintained. While the loss of comm. condition is active, the operator will have the ability to manually adjust the anticipated loading value via the HMI

H. LOAD BANK TEST

1. ENTRY INTO LOAD BANK MODE

    a. PS Master controller – Load Bank Screen, select “Load Bank Mode”. Then select the generator (1 through 10) to be tested. The Load Bank is sized to match to one generator.

b. PS Master controller shall communicate with the Load Bank Controller for a complete test.
c. The system will now run in Automatic / Standby Mode.

2. EXIT FROM LOAD BANK MODE

a. PS Master controller – Load Bank Screen, select “Load Bank Mode” off.
b. The system will be put back into Automatic/Standby Mode.

I. FAILURE RECOVERY

1. Manufacturer shall design failure recovery sequences for each operation.
2. This shall include failure recovery for the following conditions:

a. MSS Main Circuit Breaker Fail to Close
b. MSS Main Circuit Breaker Fail to Open
c. MSS Tie Circuit Breaker Fail to Close
d. MSS Tie Circuit Breaker Fail to Open
e. PS Tie Circuit Breaker Fail to Close
f. PS Tie Circuit Breaker Fail to Open
g. Generator Fail to Synchronize
h. Generator Fail to Connect
i. PS Generator Circuit Breaker Fail to Close
j. PS Generator Circuit Breaker Fail to Open
k. Extended Parallel

J. COMPLY WITH NFPA 110 FOR THE FOLLOWING:

1. Emergency: EPSS Level 1, Type 10
2. Legally Required Standby: EPSS Level 1, Type 60
3. Optional Standby: EPSS Level 1, Type 60.

END OF SECTION 261327.11

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data:

1. For each type of product.

a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
b. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

D. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Transformer temporary heating, working clearances, anchoring, torque values, and insulation-resistance testing.

E. Source quality-control reports.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat in accordance with manufacturer's published instructions within enclosure of ventilated-type units, throughout periods during which equipment is not energized and when transformer is not in space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ABB / G.E.

B. ACME

C. Eaton

D. Hammond

E. Maddox

F. Siemens

G. Sola / Hevi Duty

H. Square D / Schneider Electric

I. Source Limitations: Obtain each type of transformer from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70 and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Grounded to enclosure.

C. Coils: Continuous windings except for taps.

1. Coil Material: Aluminum or Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Welded or Bolted.

D. Enclosure: Ventilated.

1. Core and coil must be encapsulated within resin compound using vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Environmental Protection:

a. Indoor: UL 50E, Type 2 or as noted on drawing.
b. Outdoor: UL 50E, Type 3R or asnoted on drawing.

5. Finish Color: **Gray** weather-resistant enamel.

E. Taps for Transformers 3 kVA and Smaller: None.

F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

H. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with maximum of 115 deg C rise above 40 deg C ambient temperature.

I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of 150 deg C rise above 40 deg C ambient temperature.

J. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

K. Electrostatic Shielding: Windings must have independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding shield.

2.4 IDENTIFICATION

A. Nameplates:
1. Self-adhesive label for distribution transformers. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at location of transformer.

E. Environment: Enclosures must be rated for environment in which they are located.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions**,** seismic requirements applicable to Project**,** and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base in accordance with manufacturer's published instructions.

E. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.4 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Project Construction Management Representative.

B. Tests and Inspections:

1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:

a. Visual and Mechanical Inspection.

1) Inspect physical and mechanical condition.
2) Inspect anchorage, alignment, and grounding.
3) Verify that resilient mounts are free and that shipping brackets have been removed.
4) Verify that unit is clean.
5) Perform specific inspections and mechanical tests recommended by manufacturer.
6) Verify that as-left tap connections are as specified.
7) Verify presence of surge arresters and that their ratings are as specified.

b. Electrical Tests:

1) Measure resistance at windings, taps, and bolted connections.
2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

C. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.

D. Nonconforming Work:

1. Transformer will be considered defective if it does not pass tests and inspections.
2. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Assemble and submit test and inspection reports.

3.5 ADJUSTING

A. Record transformer secondary voltage at unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.7 MAINTENANCE

A. Infrared Scanning: Two months after Substantial Completion, perform infrared scan of transformer connections.

1. Use infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform one follow-up infrared scans of transformers, at 11 months after Substantial Completion.
3. Prepare certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 262213

SECTION 262300.01 - HMI DASHBOARD SYSTEM - Purchase

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. 261116.11 – Secondary Unit Substation with Switchgear Secondary.

B. 261116.12 – Secondary Unit Substation with MV Switchgear Secondary.

C. 261326 – Medium-Voltage Metal-Clad Switchgear.

D. 261327 – Medium-Voltage Paralleling Metal-Clad Switchgear.

E. 263600 – Medium-Voltage Automatic Transfer Switchgear.

1.2 SUMMARY

A. This section describes the visualization requirements for a modular, scalable HMI interface offering monitoring and control for meters, relays, gateways, trip units, High Resistance Ground units and other electronic components as installed in low and medium voltage switchgear.

B. This section includes the supply and installation of a standalone/ localized HMI Dashboard system for each switchgear line up as detailed on the drawings and described in this specification.

1.3 DEFINITIONS

A. HMI: Human Machine Interface. Sometimes called OIT, Operator Interface Terminal.

1.4 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for enclosure.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

C. Qualification Data: For factory-authorized service representative.

D. Product Test Reports: For each system, for tests performed by a qualified agency.

E. Source quality-control reports.

F. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For equipment to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in a dry, clean location, placed on a level surface to prevent strain and possible distortion. During the construction period, provide protection against dust, dirt, falling objects, dripping water, water, excessive moisture, and other possible causes of damage to the equipment. Any temporary covering shall not restrict ventilation and may not be removed until the equipment is ready for installation.

1.7 FIELD CONDITIONS

A. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Humidity Rating: Less than 95 percent (noncondensing).
3. Altitude Rating: Not exceeding 6600 feet (2000 m).

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of HMI Dashboard that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: five year(s) from date of completed startup, testing and commissioning.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. The HMI Dashboard system is defined to include, but not to be limited to, remote devices for metering, monitoring, control and protection, all Ethernet communications gateways, intercommunication wiring, ancillary equipment, startup and training services, and ongoing technical support.

2.2 MATERIALS

A. The HMI dashboard shall be equivalent to 24 inches with a resolution of 1920 x 1080 and local dashboard part of each switchgear line up shall be equivalent to 15 inches with a resolution of 1920 x 1080.

1. The HMI shall have 1.65 GHz dual core CPU with integrated Radeon HD Graphics card to support high processing power and high-performance graphics.
2. The HMI shall have minimum of two Ethernet and USD interfaces.
3. The HMI shall support and external memory card for additional storage in addition to device’s internal SSD memory.
4. The HMI shall include intuitive multi-touch functionality permitting user to zoom, scroll and swipe.

B. The HMI Dashboard shall be mounted in a control cabinet located outside the arc-flash boundary.

C. The HMI Dashboard shall use CAT6 as physical media to communicate with electronic components located in the switchgear either via an Ethernet switch or the manufacturer

Gateway. Modbus-TCP shall be preferred communication protocol between the component interface to the HMI.

D. The electronic components shall include E-Series protective relays, Circuit Breaker electronic trip unit, electronic meters, Transient Voltage Surge Suppressor and Transformer Monitoring system.

E. There shall be a HMI Dashboard dedicated for each switchgear line up, each HMI Dashboard shall offer monitoring and control for the switchgear lineup to which it is interfaced.

F. The HMI Dashboard shall display the appropriate PPE level based on data provided from an arc flash study and status of Arc Flash Reduction Mode on all the screens.

G. The HMI Dashboard must support multiple security levels such as Administrator and multiple users so that appropriate operational rights can be assigned to an operator.

H. Tapping each device shall open a new window on the HMI screen showing the details as follows:

1. Protective Relays/ Trip Units: Maintenance mode status, total trip, last trip, device alarm conditions, metering trends if supported by the device, sequence of events and cause of trip.
2. Meters: Basic metering information not limited to currents, voltages, frequency, power factor, power, energy, THD, harmonics, trends, waveforms, alarms and I/O status.
3. For meters with web interfaces the meter’s web page should be accessible through the detail screen on the HMI.

I. The HMI Dashboard shall have following tabs:

1. One-line
2. Elevation
3. Transfer
4. Timeline
5. Waveform Trending
6. Documents
7. Settings (Used for system settings)

J. Under the One Line tab the HMI Dashboard shall display system one line diagram. The one line diagrams shall include the following, but not limited to:

1. HMI Dashboard shall display source, and bus status indicated by different colors depending on energized/de-energized conditions
2. HMI Dashboard shall display breaker status (open, closed, tripped, racked in and racked out), each of the status described above shall be differentiated visually.
3. HMI Dashboard shall allow breaker control such as open, close and Arc Flash Reduction Maintenance Mode activation.

4. The one line shall display basic values from relays, trip units and meters on one line. Detailed information on an electronic component shall be available by tapping a device. The information displayed shall be in tabular format.
5. The one line shall display alarm conditions in flashing red, further information on type of alarm shall be available tapping a device.
6. PPE level for each breaker shall be displayed on the one line

K. Under the Elevation tab the graphics shall mimic the switchgear elevation or front view. The view shall include the following, but not limited to:

1. Physical representation of the switchgear including appropriate number of structures, breaker counts and breaker locations.
2. The breaker status (open, closed, tripped, racked in and racked out) shall be displayed on the elevation view, relative to physical location of the breaker.
3. HMI Dashboard shall allow breaker control such as open, close, Arc Flash Reduction Maintenance Mode activation and MV remote breaker rack in-out when the switchgear is so equipped.
4. The structure and breaker locations shall be clearly identified in this mode.
5. A color-coded mimic bus shall be displayed, bus and breaker status shall be indicated by different colors depending on energized/de-energized conditions.

L. Under Transfer tab, the graphics shall support the following:

1. The transfer scheme graphics shall work with a PLC based transfer scheme. The transfer scheme shall be limited to the transfer between the sources located within a switchgear to which HMI Dashboard will be interfaced.
2. The transfer shall show source, breaker and bus status in a color-coded fashion depending on energized/de-energized conditions.
3. The transfer scheme graphics shall be animated to show loss of voltage, countdown of timers, dead bus time as well as breaker status and bus status.
4. The transfer scheme graphic template must support an open or closed transfer scheme.
5. The transfer scheme graphics shall be pre-programmed for following configurations supported by relay transfer: Main-Tie-Main.
6. The transfer template shall provide access to change appropriate timers as required to modify a transfer scheme.
7. The graphics shall support both automatic and manual modes of transfer.
8. Sequence of operation for the transfer shall be available to view on the HMI Dashboard.

M. Under the Timeline tab, alarm or fault conditions as well as user operations and login information shall be displayed for all the electronic components interfaced with the HMI Dashboard.

1. A detailed view displaying PPE Level and protection boundary for individual breakers shall be available.
2. A graphical representation of suggested personal protection equipment (PPE) shall be displayed. The different classes of suggested PPE shall not be limited to Class G, Class E, Class 4 and EH Rated.

N. Under the Waveform Trending tab, individual breakers can be accessed to review the waveform capture and trending events. Ability to set event capture criteria and sampling rate.

O. Under Documentation tab, following documents shall be available:

1. O&M Manual for the switchgear
2. Project Specific Drawings (Elevation, three-line, BOM, wiring diagrams, etc.)
3. User Manuals for Electronic components such as Protective Relays/ Trip Units, Meters and any other devices as seemed suitable by the end user.
4. Breaker Manuals
5. Coordination studies

PART 3 - EXECUTION

3.1 IDENTIFICATION

A. Provide labels and signs for the cabinet and HMI system.

B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service shall test and inspect components, assemblies, and equipment installations, including connections.

3.3 STARTUP SERVICE

A. Manufacturer's Field Service shall perform startup service.

1. Complete installation and startup checks per manufacturer's written instructions.

3.4 DEMONSTRATION

A. Manufacturer's Field Service shall train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 262300.01

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Switchboards.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

1.2 SUBMITTALS

A. Product Data:

1. Switchboards.
2. Overcurrent protective devices.
3. Surge protection devices.
4. Groud-fault protection devices.
5. Accessories.
6. Other components.
7. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types.
3. Detail bus configuration, current, and voltage ratings.

4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit in electronic PDF format; include selectable ranges for each type of overcurrent protective device.
7. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:

1. Field Quality-Control Reports:

a. Test procedures used.
b. Test results that comply with requirements.
c. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Handling, storing, and providing temporary heat.
2. Mounting accessories and anchoring devices.
3. Testing and adjusting overcurrent protective devices.

1.3 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.4 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays. Furnish to Owner during demonstration.

B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to switchboards, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation in accordance with NECA 400.

1.7 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed switchboard perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that switchboard performs in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
2. Follow-On Extended-Warranty Period: Five years from date of Substantial Completion; full coverage for materials that failed because of transient voltage surges only, free on board destination, freight prepaid.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; Schneider Electric USA.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

D. Comply with NEMA PB 2.

E. Comply with NFPA 70.

F. Comply with UL 891.

G. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

H. Nominal System Voltage: 480Y/277 V or as indicated on drawings.

I. Main-Bus Continuous: 1600A, or as indicated on the drawings.

J. Indoor Enclosures: Steel, UL 50E, Type 1.

K. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over rust-inhibiting primer on treated metal surface.

L. Barriers: Between adjacent switchboard sections.

M. Customer Metering Compartment: Separate customer metering compartment and section with front hinged door for indicated metering, and current transformers for each meter. Current transformer secondary wiring must be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

1. Meter Compartment: Meter shall be in a compartment isolated from any energized bus. The metering compartment shall include following:
   a. Be furnished complete with a disconnect switch to disconnect power to the meter and associated components.
   b. Be furnished complete with C.T. shorting block.
   c. Be designed with guarding in place such that all components in the metering compartment are “finger safe” with respect to voltage above 50 volts.
   d. Be furnished with a 1” flexible non-metallic conduit routed from the metering compartment to the exterior of the switchgear.

N. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

O. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from front of switchboard.
2. Phase- and Neutral-Bus Material:

    a. Hard-drawn copper of 98 percent conductivity.
    b. Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
    c. Copper is base bid, Aluminum is Alternate.

3. Copper feeder circuit-breaker line connections. Base Bid.
4. Tin-plated aluminum feeder circuit-breaker line connections. Alternate.
5. Ground Bus: 1/4 by 2 inch hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
7. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

8. Neutral Buses: 100 percent of ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

P. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 SURGE PROTECTION DEVICES

A. Provide surge protection equipment as specified in 264313 “Surge Protective Devices for Low-Voltage Electrical Power Circuits” for details.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Provide overcurrent protection devices as specified in 262816 “Switches and Circuit Breakers” for details.

2.4 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy must be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound window type; single secondary winding and secondary shorting device. Burden and accuracy must be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.
f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

3. Provide a multifunction digital meter for each breaker that does not contain integral metering of comparable type to that listed above.

C. Electrical Power Wiring: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Copper conductors are Type THHN/THWN-2.
2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards in accordance with NEMA PB 2.1.

1. Lift or move switchboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's published instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage in accordance with manufacturer's published instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect performance of equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Switchboards and Accessories: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA PB 2.1.
2. Consult Engineer for resolution of conflicting requirements.

C. Special Techniques:

1. Equipment Mounting: Install switchboards on concrete base, 4 inch nominal thickness. Concrete base specified on Structural sheets.

a. Install conduits entering underneath switchboard, entering under vertical section where conductors will terminate. Install with couplings flush with concrete base. Extend 2 inch above concrete base after switchboard is anchored in place.
b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around full perimeter of concrete base.
c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, published instructions, and directions furnished with items to be embedded.
e. Install anchor bolts to elevations required for proper attachment to switchboards.
f. Anchor switchboard to building structure at top of switchboard if required or recommended by manufacturer.

2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Operating Instructions: Frame and mount printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
5. Install filler plates in unused spaces of panel-mounted sections.
6. Install overcurrent protective devices, surge protection devices, and instrumentation.

a. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Bond conduits entering underneath switchboard to equipment ground bus with bonding conductor sized in accordance with NFPA 70.

B. Support and secure conductors within switchboard in accordance with NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Acceptance Testing:

a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Perform the following infrared scan tests and inspections, and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joint and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated and/or as specified in Section 260573.16 "Coordination Studies."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Electronic-grade panelboards.

B. RELATED REQUIREMENTS

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Key interlock scheme drawing and sequence of operations.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit an Internet link for electronic access to downloadable PDF of the coordination curves.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.

B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to panelboards, that are packaged with protective covering for storage on-site and identified with labels describing contents.

1. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays. Turn over to Owner after demonstration.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.9 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.

b. Altitude: Not exceeding 6600 feet.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 24 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Height: 84 inches maximum.
3. Hinged Front Cover (Door-In-Door): Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware. Two (2) self latching locks for door-in-door construction with concealed trim clamps. One (1) lock shall be used to gain access to the breaker switches, but not exposed to energized parts. Panelboards shall require the use of two things to access energized parts: a key and a hand held tool (screwdriver) to open the cover that exposes energized parts.
4. Panelboards' wiring gutter shall be a minimum of the manufacturer's standard width or larger based on the following panelboard sizes:

a. Up to 225A: Standard gutter width is acceptable unless more than (42)pole.
b. Greater than 225A through and including 400A: 4 additional inches shall be added on each side of the standard gutter.

5. Finishes:

a. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Galvanized steel.

6. Directory Card: Inside panelboard door, mounted in transparent card holder or metal frame with transparent protective cover.

G. Incoming Mains:

1. Location: Top and/or Bottom; Coordinate with installing contractor prior to order the equipment.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.
b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Silver or Tin-plated Copper.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.

J. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: Minimum of 10 percent and as specified on panelboard schedule.

K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 22,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB: ReliGear neXT Power Panel.
2. Eaton Corporation: Pow-R-Line P3A and P4.
3. Siemens Industry, Inc.: P4 and P5 Series.
4. Square D; by Schneider Electric: I-line Series.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker; Molded case Switch or Main lugs only as specified on panelboard schedule.

E. Branch Overcurrent Protective Devices for Circuit-Breaker: Bolt-on circuit breakers or Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB: AE/RE/AS/RS Series.
2. Eaton Corporation: Pow-R-Line 1a, 2a and 3a.
3. Siemens Industry, Inc.: P1, P2 and P3 Series.
4. Square D; by Schneider Electric: NQ and NF Series.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker; Molded case Switch or Main lugs only as specified on panelboard schedule.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed. Two (2) self latching locks for door-in-door construction with concealed trim clamps. One (1) lock shall be used to gain access to the breaker switches, but not exposed to energized parts. Panelboards shall require the use of two things to access energized parts: a key and a handheld tool (screwdriver) to open the cover that exposes energized parts.

2.5 OVERCURRENT PROTECTIVE DEVICES

A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

B. Refer to division 26 specification section Switches and Circuit breaker for specification.

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in transparent card holder or metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.7 SURGE PROTECTION DEVICE

A. Provide surge protection device specified in division 26 “Surge protective Device”, where shown on contract document.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:
   1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
   2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches above finished floor unless otherwise indicated. Mount top of the protective device operating handle not to exceed 74” above finish floor.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 GROUNDING

A. Provide grounding and bonding in accordance with DIVISION 26 section “Grounding and Bonding for Electrical Systems”.
1. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on isolated/insulated ground bus.
2. Terminate branch circuit isolated grounding conductors on isolated/insulated ground bus only. Do not terminate on solidly bonded equipment ground bus.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

a. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Engineer of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.7 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. Automatic Control Indicator receptacles, 125V, 20A.
3. GFCI receptacles, 125 V, 20 A.
4. Hazardous (classified) location receptacles.
5. Twist-locking receptacles.
6. Toggle switches, 120/277 V, 20 A.
7. Wall plates.

1.3 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Device Color:

1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Essential Electrical System: Red.

F. Wall Plate Color: For plastic covers, match device color.

G. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 CONVENIENCE RECEPTACLES, 125 V, 20 A

A. Convenience Receptacles, Premium Industrial Grade, 125 V, 20 A, Configuration 5-20R.:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Eaton (Arrow Hart); 5361 (single), AH5362 (duplex).
b. Hubbell; HBL5361 (single), HBL5362 (duplex).
c. Leviton; 5361 (single), 5362 (duplex).
d. Pass & Seymour; 5361 (single), 5362A (duplex).

2. Description: Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 1 and NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596H.

2.3 AUTOMATIC CONTROL INDICATOR RECEPTACES, 125V, 20A

A. Specification and configuration equal to Standard-Grade Receptacles Article.

1. Duplex receptacle shall have the universal controlled receptacle marking symbol imprinted on the face at each receptacle.
2. Duplex receptacle shall have the word “CONTROLLED” imprinted on the face at each receptacle.
3. Receptacle color shall be green, cover plate color to match standard receptacles.

a. Equal to Hubbell; BR20C2GN.

2.4 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart) – SGF20.
b. Hubbell Incorporated; Wiring Device-Kellems – GFRST20.
c. Leviton Manufacturing Co., Inc – G5362.
d. Pass & Seymour/Legrand (Pass & Seymour) - 2097.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.5 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Configuration: NEMA WD 6, Configuration L5-20R.
3. Standards: Comply with UL 498.

2.6 TOGGLE SWITCHES, 120/277 V, 20 A

A. Switches, Premium Industrial Grade, back and side wire terminals, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart); AH1221.
b. Hubbell Incorporated; Wiring Device-Kellems; HBL1221.
c. Leviton Manufacturing Co., Inc;1221-2.
d. Pass & Seymour/Legrand (Pass & Seymour); PS20AC1.

2. Standards: Comply with UL 20 and FS W-S-896.

2.7 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for interior Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in damp locations.

C. Wet-Location, Weatherproof While-In-Use Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover for unattended use per NEC.

1. Products: Subject to compliance with requirements, provide one of the following for receptacles:

a. Hubbell; MX4280/MX4380/MX7280 (color as selected by architect).
b. Intermatic equal.
c. Eaton (Cooper) equal.
d. Leviton equal.
e. Pass & Seymour equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.

7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical. Group adjacent switches under single, multigang wall plates.

3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number as specified in “Identification Section”, and durable wire markers or tags inside outlet boxes.

C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:

1. In healthcare facilities, prepare reports that comply with NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions remove malfunctioning units and replace with new ones, and retest as specified above.

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

    a. Control circuits.
    b. Enclosed controllers.
    c. Enclosed switches.

1.3 SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in PDF format.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in PDF format.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bussmann, an Eaton business.
2. Littelfuse, Inc.
3. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250 and 600-V, zero- to 600-A rating, 200 kAIC**,** time delay.
2. Type RK-5: 250 and 600-V, zero- to 600-A rating, 200 kAIC**,** time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC**,** fast-acting or time-delay.
4. Type J: 600-V, zero- to 600-A rating, 200 kAIC**,** fast-acting or time delay.
5. Type L: 600-V, 601- to 6000-A rating, 200 kAIC**,** time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
1. Control Transformer Circuits: Class CC, time delay, control transformer duty.
2. Feeders: Class L, time delay, Class RK1, time delay, Class RK5, time delay, Class J, time delay.
3. Motor Branch Circuits: Class RK1, Class RK5, Class CC, motor duty, time delay.
4. Large Motor Branch (601-4000 A): Class L, time delay.
5. Power Electronics Circuits: Class J, high speed, fast-acting.
6. Other Branch Circuits: Class RK1, time delay, Class RK5, time delay, Class J, time delay, Class CC, fast acting.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. Include time-current coordination curves for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

B. Shop Drawings: For switches and circuit breakers.

1. Include wiring diagrams for power, signal, and control wiring.

C. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 Field quality-control reports.

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB – TH series with visible blade.
2. Eaton - DH series with visible blade.
3. SIEMENS Industry, Inc.; – VB-2 series with visible blade.
4. Square D; by Schneider Electric – H series with visible blade.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 240 and 600-V ac.
4. 1200 A and smaller.

5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified and/or indicated fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit where applicable: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Aux Switch where applicable: Internally mounted; Application for door open switch feedback for VFD operation.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.4 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB – TH series with visible blade.
2. Eaton - DH series with visible blade.
3. SIEMENS Industry, Inc.; – VB-2 series with visible blade.
4. Square D; by Schneider Electric – H series with visible blade.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit where applicable: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Aux Switch where applicable: Internally mounted; Application for door open switch feedback for VFD operation.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Molded Case Fixed Trip Unit, 15A to 50A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB – TEY.
b. Eaton – Power Defense Frame 2.
c. SIEMENS Industry, Inc. –BLH, HBL, 3VA Series.
d. Square D; by Schneider Electric – HL series.

2. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
3. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.
4. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker.
5. The MCCBs shall have provision for Lock-Out / Tag-Out capable of accepting padlocks.

B. Lugs shall be suitable for 194 deg F (90 deg C) rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.

1. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents and as specified in contract document.

C. Molded Case Electronic Trip Unit (LI), 60A to 225A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following for electronic trip unit breaker:

a. ABB –SACE Tmax XT W/Ekip Dip trip unit.
b. Eaton – Power Defense Frame 2 with PXR10, 20.
c. Siemens Industry, Inc.– 3VA61 W/Trip unit ETU 320.
d. Square D: – Power Pact - H, J Frame with 3.3-Dial.

2. Electronic Trip Unit: Equipped with self-powered, microprocessor-based trip device to sense overload and short circuit conditions. The device shall measure true RMS current. The tripping system shall consist of high accuracy (less than 1%) coil sensors on each phase, a release mechanism, Field Installable and interchangeable front mounted trip units. The trip unit shall include Dial Type. Trip units shall be designed to be upgraded for future expansion in functionality, such as communication, with the following field-adjustable functions for 50 ampere and up to 225 ampere:

a. Functions: Long term, and instantaneous protection function.
b. Each shall have an adjustable pick-up setting.
c. Current Adjustability shall be accomplished by use of dial settings keypad and rating plugs on trip units.
d. Pickup Points: Minimum of 8 field adjustable Settings.

3. The MCCBs shall have provision for Lock-Out / Tag-Out capable of accepting padlocks.

D. Molded Case Electronic Trip Unit (LSI), 250A to 1200A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following for electronic trip unit breaker (LSIG):

a. ABB –SACE Tmax XT W/Ekip Dip trip unit.
b. Eaton: Power Defence Frame 3-5 with PXR20, 20D or 25 trip units.
c. Siemens Industry, Inc.: 3VA61 W/Trip unit ETU 350\550.
d. Square D; by Schneider Electric Power pact - HJ, JJ, LJ, & PJ Frame with 5.3A trip unit.

2. Electronic Trip Unit: Equipped with self-powered, microprocessor-based trip device to sense overload and short circuit conditions. The device shall measure true RMS current. The tripping system shall consist of high accuracy (less than 1%) coil sensors on each phase, a release mechanism, Field Installable and interchangeable front mounted trip units. The trip units shall be designed to be upgraded for future expansion in functionality, such as communication, with the following field-adjustable functions for 250 ampere and up to 1200 ampere:

a. Functions: Long term, short term, and instantaneous protection and Arc Flash reduction.
b. Each shall have an adjustable pick-up setting. In addition, long time and short time bands shall each have adjustable time delay. Short time function shall include a switchable I2t ramp and optionally i4t to improve coordination with fuses or inverse relays.
c. Individual LEDs/LCD shall indicate an over-current, short-circuit, or ground-fault trip condition.
d. Current Adjustability shall be accomplished by use of dial settings keypad and rating plugs on trip units or LCD display with device plugin.
e. Pickup Points: Minimum of 8 field adjustable Settings.
f. A LCD display if specified shall be provided to simplify settings and viewing data locally.
g. Where specified provide remotely switch protection settings.

E. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

F. MCCBs shall have provision for Lock-Out / Tag-Out capable of accepting padlocks.

G. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Shunt Trip where applicable: Trip coil energized from separate circuit, with coil-clearing contact.

2.6 POWER CIRCUIT BREAKER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB: SS Series w\ programmable (ETU).
2. Eaton: Power Defense NF, RF & Frame 6 with PXR trip unit.
3. SIEMENS Industry, Inc.; Energy Management Division WL Series w\ETU 776.
4. Square D; by Schneider Electric: NT, NW Series w\ ETU-6A or RK Series w/ETU-6A.

B. Circuit Breaker: 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current and as specified on contract document.
1. Fixed or Drawout circuit-breaker mounting, noted on drawings. Circuit breaker cell sizes shall have a common height and depth. Breaker frames of the same size shall be fully interchangeable.
2. Two-step, stored-energy closing. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation. Slow closing speed shall not be required to properly maintain the breaker contacts.
3. Circuit breakers shall be constructed and tested in accordance with ANSI C37.13, C37.16, C37.17, C37.50, UL 1066 and NEMA SG-3 standard. The breaker shall carry a UL label.
4. The breaker shall be Manual or Electrically operated, noted on drawings. Electrically operated breakers shall be complete with 120 Vac, 24 Vdc or 125 Vdc motor operators, noted on drawings. The charging time of the motor shall not exceed 6 seconds.
5. To facilitate lifting, the circuit breaker shall have integral handles on the side of the breaker.
6. The circuit breaker shall have a closing time of not more than 3 cycles.
7. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.
8. The circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.
9. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions, as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The circuit breaker shall have a “Positive On” feature. The breaker flag will read “Closed” if the contacts are welded and the breaker is tripped or opened.
10. The current sensors shall have a back cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug will offer indication of the rating on the front of the trip unit. The current sensor and rating plug shall be of the same current rating.
11. A position indicator shall be located on the faceplate of the breaker. This indicator shall provide color indication of the breaker position in the cell. These

positions shall be Connect (Red), Test (Yellow), and Disconnect (Green). The levering door shall be interlocked so that when the breaker is in the closed position, the breaker levering-in door shall not open.

12. Each circuit breaker cell shall have front-mounted dedicated secondary wiring points. Each wiring point shall have finger safe contacts, which will accommodate #10 AWG maximum field connections with ring tongue, spade terminals or bare wire.

C. Electronic Trip Unit: Equipped with self-powered, microprocessor-based trip device to sense overload and short circuit conditions. The device shall measure true RMS current. The tripping system shall consist of high accuracy (less than 1%) coil sensors on each phase, a release mechanism, Field Installable and interchangeable front mounted trip units. The trip unit shall include LCD Display type.

D. The trip unit shall have an information system that utilizes battery backup LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip. A test pushbutton shall energize a LED to indicate the battery status.

E. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.

F. The trip unit shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.

G. Trip unit shall have selectable powered and unpowered thermal memory for enhanced circuit protection.

H. The trip unit shall include a power/relay module which shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available.

I. Trip units shall be designed to be upgraded for future expansion in functionality, such as communication, with the following field-adjustable functions:

a. Functions: Long term, short term, and instantaneous protection function shall be providing (EIP) to allow the breaker to be applied at the withstand rating for the breaker with minus 0% tolerance so that there is not instantaneous override whatsoever.

b. Each shall have an adjustable pick-up setting. In addition, long time and short time bands shall each have adjustable time delay. Short time function shall include a switchable I2t ramp and optionally i4t to improve coordination with fuses or inverse relays.

c. Individual LEDs/LCD shall indicate an over-current, short-circuit, or ground-fault trip condition.

d. Current Adjustability shall be accomplished by use of dial settings keypad and rating plugs on trip units or LCD display with device plugin.
e. Pickup Points: Minimum of 8 field adjustable Settings.
f. Ground-fault protection, where specified, provide with at least three time-delay bands and an adjustable current pickup and an I2t ramp. Arrange to provide protection for four-wire service as stated on the contract documents.
g. Provide with remotely switch protection settings.
h. The trip unit shall be equipped to permit communication for remote monitoring and control.

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Communication Capability: Circuit-breaker-mounted Integral communication module with following functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control." And as follow:
   a. Metering display accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.
   b. The unit shall monitor the following data:
      1) Instantaneous value of phase, neutral and ground current
      2) Instantaneous value of line-to-line voltage
      3) Minimum and maximum current values
      4) Watts, vars, VA, watthours, varhours and VA hours
   c. The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit’s alphanumeric display panel.
   d. The trip unit shall display the following power quality values: crest factor, power factor, percent total harmonic distortion, and harmonic values of all phases through the 31st harmonic.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: One NO and NC contact that operates only when circuit breaker has tripped.
9. Key Interlock Kit where applicable: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

10. The trip unit shall contain an integral test pushbutton. A keypad shall be provided to enable the user to select the values of test currents within a range of available settings. The protection functions shall not be affected during test operations. The breaker may be tested in the TRIP or NO TRIP test mode.
11. Programming may be done via a keypad at the faceplate of the unit or via the communication network.
12. The trip unit shall offer a three-event trip log that will store the trip data, and shall time and date stamp the event.
13. The MCCBs shall have provision for Lock-Out / Tag-Out capable of accepting padlocks.

K. Arc Flash Reduction Function: The trip unit shall utilize ARMs Technology (Arc Flash Reduction Maintenance System). The ARMs Technology shall be provided in a system that shall reduce the trip unit Instantaneous pickup value when activated. The ARMs device shall not compromise breaker phase protection even when enabled. Once the ARMs unit is disabled, the recalibration of trip unit phase protection shall not be required. Activation and deactivation of the ARMs Technology trip setting shall be accomplished without opening the circuit breaker door and exposing operators to energized parts. The ARMs Technology shall provide a clearing time of 0.04 seconds, adjustable with a minimum of five settings ranging from 2.5X to 10X of the sensor value.

1. The ARMs Technology shall be enabled via a switch on the trip unit. It shall also provide confirmation of protection via a Blue LED.
2. The ARMs Technology shall be provided with remote “enable/disable” control
3. The ARMs Technology shall be provided with a switchgear panel mounted enable pad lockable selector switch and indication via Blue LED pilot light.
4. The ARMs Technology shall be wired locally with interposing relays and wired to terminal blocks to enable a remote selector switch and confirmation light to be mounted the downstream protected distribution equipment.

L. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

M. MCCBs shall have provision for Lock-Out / Tag-Out capable of accepting padlocks.

N. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection where applicable: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip where applicable: Trip coil energized from separate circuit, with coil-clearing contact.
5. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

6. Zone-Selective Interlocking where applicable: Integral with electronic and/or ground-fault trip unit; for interlocking ground-fault protection function.
7. Electrical Operator where applicable: Provide remote control for on, off, and reset operations.
8. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac.

2.7 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure to override the interlock.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than fourteen days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Construction Manager's written permission.
4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.

2. Outdoor, Wet Locations (typical): NEMA 250, Type 3R, or as noted on drawings.

3. Outdoor, Wet Locations exposed to cooling tower water: NEMA 250, Type 4X Stainless Steel.

3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, grounding, and clearances.
   c. Verify that the unit is clean.
   d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
   e. Verify that fuse sizes and types match the Specifications and Drawings.
   f. Verify that each fuse has adequate mechanical support and contact integrity.
   g. Inspect bolted electrical connections for high resistance using one of the two following methods:

      1) Use a low-resistance ohmmeter.

         a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

         a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

   h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
   i. Verify correct phase barrier installation.
   j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that

deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.

d. Verify that the unit is clean.

e. Operate the circuit breaker to ensure smooth operation.

f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.

h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to

values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.

e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.

g. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.

h. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges to values indicated in the final settings established in specification 260573.16 Coordination Studies. Settings provided in specification 262816.11 Breaker and Relay Settings, may be used for initial setting and testing before the final settings are available.

END OF SECTION 262816

SECTION 262816.11 - PROTECTIVE DEVICE SETTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260573.13 “Short Circuit Studies”.
4. Section 260573.16 “Coordination Studies”.
5. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.
6. Section 262816 “Switches and Circuit Breakers”.

1.2 SUMMARY

A. A table for Protective Device Settings is provided so setting values may be entered, allowing the contractor and manufacturer field services to begin startup and testing, before the final setting values are provided per the system short circuit and coordination studies and arc-flash hazard analysis.

B. Eaton products were used as the basis of design for the main switchgear, unit substations and down stream switchboards and panelboards.

C. Square D products were used for the paralleling gear and MV-ATS gear.

PART 2 - PRODUCTS – Not Used:

PART 3 - EXECUTION

3.1 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than fourteen days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.
4. Comply with NFPA 70E.

3.2 SETTINGS

A. Set field-adjustable circuit-breaker trip ranges to values indicated in the final settings established in specification 260573.16 Coordination Studies. Settings provided in specification 262816.11 Breaker and Relay Settings, may be used for initial setting and testing before the final settings are available.

PART 4 - TABLE FOR PROTECTIVE DEVICE SETTINGS

END OF SECTION 262816.11

Protective Device Settings

	A	B	C	D	E
1	**Project: 21-154 Central Utility Plant Electrical Model**			**Row #**	
2	**Scenario: Base Project**		**LV Breakers:**	6	
3	**IU Health - Central Utility Plant**		**MV Breakers:**	1386	
4	**IU Health Hospital**		**Relays:**	1774	
5			**Fuses:**	3667	
6	**LV Breakers**				
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
8	PD-1NH1 MAIN	EATON	250.0A	Interrupting 65.0	Ir G (225A)
9	Static Trip	LG Frame, 310+	250.0A		tr 7
10			250.0A		Isd 6 (1350A)
11					tsd Fixed (I^s T On)
12					Ii OR Fixed (3000A)
13					
14	PD-1NH1:1NL1 (T-1NL1)	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
15	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
16			125.0A		STPU (2 - 12 x Ir) 2 (250A)
17					INST OR Fixed (3000A)
18					
19	PD-1NH3:1NL2 (T-1NL2)	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
20	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
21			125.0A		STPU (2 - 12 x Ir) 2 (250A)
22					INST OR Fixed (3000A)
23					
24	PD-1NH4:1NL3 (T-1NL3)	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
25	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
26			125.0A		STPU (2 - 12 x Ir) 2 (250A)
27					INST OR Fixed (3000A)
28					
29	PD-1NL1 MAIN	EATON	250.0A	Interrupting 65.0	Ir F (200A)
30	Static Trip	LG Frame, 310+	250.0A		tr 7
31			250.0A		Isd 6 (1200A)
32					tsd Fixed (I^s T On)
33					Ii OR Fixed (3000A)
34					
35	PD-1NL2 MAIN	EATON	250.0A	Interrupting 65.0	Ir F (200A)
36	Static Trip	LG Frame, 310+	250.0A		tr 7
37			250.0A		Isd 6 (1200A)
38					tsd Fixed (I^s T On)
39					Ii OR Fixed (3000A)
40					
41	PD-1NL3 MAIN	EATON	250.0A	Interrupting 65.0	Ir F (200A)
42	Static Trip	LG Frame, 310+	250.0A		tr 7
43			250.0A		Isd 6 (1200A)
44					tsd Fixed (I^s T On)
45					Ii OR Fixed (3000A)
46					
47	PD-2LSH1 : 1LSH1	EATON	250.0A	Interrupting 65.0	Ir G (225A)
48	Static Trip	LG Frame, 310+	250.0A		tr 7
49			250.0A		Isd 6 (1350A)
50					tsd Fixed (I^s T On)
51					Ii OR Fixed (3000A)
52					
53	PD-2LSH1 : 2LSH2	EATON	250.0A	Interrupting 65.0	Ir G (225A)
54	Static Trip	LG Frame, 310+	250.0A		tr 7
55			250.0A		Isd 6 (1350A)
56					tsd Fixed (I^s T On)
57					Ii OR Fixed (3000A)
58					
59	PD-2LSH1 MAIN	EATON	800.0A	Interrupting 100.0	Phase
60	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
61			800.0A	Short Time 85.0	tr (I2t) 2
62					Isd 2.5 (2000A)
63					tsd (Flat) 0.1

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
64					Ii 6 (4800A)
65					Ground
66					Ig (In<1200A) 1 (800A)
67					tg (Flat) 0.2
68					ARMS (Maint)
69					Ir 1 (800A)
70					tr (I2t) 2
71					Isd 2 (1600A)
72					tsd (Flat) 0.1
73					Ii 2 (1600A)
74					
75	PD-2NH1:2NL1 (T-2NL1)	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
76	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
77			125.0A		STPU (2 - 12 x Ir) 2 (250A)
78					INST OR Fixed (3000A)
79					
80	PD-2NH2:2NL2 (T-2NL2)	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
81	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
82			125.0A		STPU (2 - 12 x Ir) 2 (250A)
83					INST OR Fixed (3000A)
84					
85	PD-2NL1 MAIN	EATON	250.0A	Interrupting 65.0	Ir F (200A)
86	Static Trip	LG Frame, 310+	250.0A		tr 7
87			250.0A		Isd 6 (1200A)
88					tsd Fixed (I^s T On)
89					Ii OR Fixed (3000A)
90					
91	PD-2NL2 MAIN	EATON	250.0A	Interrupting 65.0	Ir F (200A)
92	Static Trip	LG Frame, 310+	250.0A		tr 7
93			250.0A		Isd 6 (1200A)
94					tsd Fixed (I^s T On)
95					Ii OR Fixed (3000A)
96					
97	PD-ESS-CUP (2A):ATS5-LS1	EATON	800.0A	Interrupting 100.0	Phase
98	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
99			800.0A	Short Time 85.0	tr (I2t) 2
100					Isd 2.5 (2000A)
101					tsd (Flat) 0.1
102					Ii 6 (4800A)
103					Ground
104					Ig (In<1200A) 1 (800A)
105					tg (Flat) 0.2
106					ARMS (Maint)
107					Ir 1 (800A)
108					tr (I2t) 2
109					Isd 2 (1600A)
110					tsd (Flat) 0.1
111					Ii 2 (1600A)
112					
113	PD-ESS-CUP (2B):ATS5-EL1	EATON	800.0A	Interrupting 100.0	Phase
114	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
115			800.0A	Short Time 85.0	tr (I2t) 2
116					Isd 2.5 (2000A)
117					tsd (Flat) 0.1
118					Ii 6 (4800A)
119					Ground
120					Ig (In<1200A) 1 (800A)
121					tg (Flat) 0.2
122					ARMS (Maint)
123					Ir 1 (800A)
124					tr (I2t) 2
125					Isd 2 (1600A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
126					tsd (Flat) 0.1
127					Ii 2 (1600A)
128					
129	PD-ESS-CUP (2C):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
130	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
131			1600.0A	Short Time 85.0	tr (I2t) 0.5
132					Isd 1.5 (2400A)
133					tsd (Flat) 0.05
134					Ii 2 (3200A)
135					Ground
136					Ig (In>=1200A) 1 (1200A)
137					tg (Flat) 0.2
138					ARMS (Maint)
139					Ir 1 (1600A)
140					tr (I2t) 0.5
141					Isd 1.5 (2400A)
142					tsd (Flat) 0.05
143					Ii 2 (3200A)
144					
145	PD-ESS-CUP (2D):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
146	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
147			1600.0A	Short Time 85.0	tr (I2t) 0.5
148					Isd 1.5 (2400A)
149					tsd (Flat) 0.05
150					Ii 2 (3200A)
151					Ground
152					Ig (In>=1200A) 1 (1200A)
153					tg (Flat) 0.2
154					ARMS (Maint)
155					Ir 1 (1600A)
156					tr (I2t) 0.5
157					Isd 1.5 (2400A)
158					tsd (Flat) 0.05
159					Ii 2 (3200A)
160					
161	PD-ESS-CUP (3A):ATS5-EQ1	EATON	800.0A	Interrupting 100.0	Phase
162	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
163			800.0A	Short Time 85.0	tr (I2t) 2
164					Isd 2.5 (2000A)
165					tsd (Flat) 0.1
166					Ii 6 (4800A)
167					Ground
168					Ig (In<1200A) 1 (800A)
169					tg (Flat) 0.2
170					ARMS (Maint)
171					Ir 1 (800A)
172					tr (I2t) 2
173					Isd 2 (1600A)
174					tsd (Flat) 0.1
175					Ii 2 (1600A)
176					
177	PD-ESS-CUP (3B):SPARE	EATON	800.0A	Interrupting 100.0	Phase
178	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
179			800.0A	Short Time 85.0	tr (I2t) 2
180					Isd 2.5 (2000A)
181					tsd (Flat) 0.1
182					Ii 6 (4800A)
183					Ground
184					Ig (In<1200A) 1 (800A)
185					tg (Flat) 0.2
186					ARMS (Maint)
187					Ir 1 (800A)

Protective Device Settings

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
188					tr (I2t) 2
189					Isd 2 (1600A)
190					tsd (Flat) 0.1
191					Ii 2 (1600A)
192					
193	PD-ESS-CUP (3C):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
194	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
195			1600.0A	Short Time 85.0	tr (I2t) 0.5
196					Isd 1.5 (2400A)
197					tsd (Flat) 0.05
198					Ii 2 (3200A)
199					Ground
200					Ig (In>=1200A) 1 (1200A)
201					tg (Flat) 0.2
202					ARMS (Maint)
203					Ir 1 (1600A)
204					tr (I2t) 0.5
205					Isd 1.5 (2400A)
206					tsd (Flat) 0.05
207					Ii 2 (3200A)
208					
209	PD-ESS-CUP (3D):FIRE PUMP1	EATON	2500.0A	Interrupting 100.0	Phase
210	Static Trip	Magnum PXR 25	2500.0A	Override 85.0	Ir 0.4 (1000A)
211			2500.0A	Short Time 85.0	tr (I2t) 3
212					Isd 4 (4000A)
213					tsd (Flat) 0.05
214					Ii 5 (12500A)
215					Ground
216					Ig (In>=1200A) 1 (1200A)
217					tg (Flat) 0.2
218					ARMS (Maint)
219					Ir 1 (2500A)
220					tr (I2t) 0.5
221					Isd 1.5 (3750A)
222					tsd (Flat) 0.05
223					Ii 2 (5000A)
224					
225	PD-ESS-CUP (4A):ATS5-GEN	EATON	800.0A	Interrupting 100.0	Phase
226	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
227			800.0A	Short Time 85.0	tr (I2t) 2
228					Isd 2.5 (2000A)
229					tsd (Flat) 0.1
230					Ii 6 (4800A)
231					Ground
232					Ig (In<1200A) 1 (800A)
233					tg (Flat) 0.2
234					ARMS (Maint)
235					Ir 1 (800A)
236					tr (I2t) 2
237					Isd 2 (1600A)
238					tsd (Flat) 0.1
239					Ii 2 (1600A)
240					
241	PD-ESS-CUP (4B):SPARE	EATON	800.0A	Interrupting 100.0	Phase
242	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
243			800.0A	Short Time 85.0	tr (I2t) 2
244					Isd 2.5 (2000A)
245					tsd (Flat) 0.1
246					Ii 6 (4800A)
247					Ground
248					Ig (In<1200A) 1 (800A)
249					tg (Flat) 0.2

Protective Device Settings

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
250					ARMS (Maint)
251					Ir 1 (800A)
252					tr (I2t) 2
253					Isd 2 (1600A)
254					tsd (Flat) 0.1
255					Ii 2 (1600A)
256					
257	PD-ESS-CUP (4C):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
258	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
259			1600.0A	Short Time 85.0	tr (I2t) 0.5
260					Isd 1.5 (2400A)
261					tsd (Flat) 0.05
262					Ii 2 (3200A)
263					Ground
264					Ig (In>=1200A) 1 (1200A)
265					tg (Flat) 0.2
266					ARMS (Maint)
267					Ir 1 (1600A)
268					tr (I2t) 0.5
269					Isd 1.5 (2400A)
270					tsd (Flat) 0.05
271					Ii 2 (3200A)
272					
273	PD-ESS-CUP (4D):FIRE PUMP2	EATON	2500.0A	Interrupting 100.0	Phase
274	Static Trip	Magnum PXR 25	2500.0A	Override 85.0	Ir 0.4 (1000A)
275			2500.0A	Short Time 85.0	tr (I2t) 3
276					Isd 4 (4000A)
277					tsd (Flat) 0.05
278					Ii 5 (12500A)
279					Ground
280					Ig (In>=1200A) 1 (1200A)
281					tg (Flat) 0.2
282					ARMS (Maint)
283					Ir 1 (2500A)
284					tr (I2t) 0.5
285					Isd 1.5 (3750A)
286					tsd (Flat) 0.05
287					Ii 2 (5000A)
288					
289	PD-ESS-CUP-MAIN	EATON	3200.0A	Interrupting 100.0	Phase
290	Static Trip	Magnum PXR 25	3200.0A	Override 85.0	Ir 1 (3200A)
291			3200.0A	Short Time 85.0	tr (I2t) 1
292					Isd 2 (6400A)
293					tsd (Flat) 0.11
294					Ii 5 (16000A)
295					Ground
296					Ig (In>=1200A) 1 (1200A)
297					tg (Flat) 0.2
298					ARMS (Maint)
299					Ir 1 (3200A)
300					tr (I2t) 0.5
301					Isd 1.5 (4800A)
302					tsd (Flat) 0.05
303					Ii 2 (6400A)
304					
305	PD-MECH1-BUS A (2A):HRC1	EATON	800.0A	Interrupting 100.0	Phase
306	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
307			800.0A	Short Time 85.0	tr (I2t) 2
308					Isd 3 (2400A)
309					tsd (Flat) 0.05
310					Ii 6 (4800A)
311					Ground

Protective Device Settings

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
312					Ig (In<1200A) 1 (800A)
313					tg (Flat) 0.2
314					ARMS (Maint)
315					Ir 1 (800A)
316					tr (I2t) 0.5
317					Isd 1.5 (1200A)
318					tsd (Flat) 0.05
319					Ii 2 (1600A)
320					
321	PD-MECH1-BUS A (2B):HRC3	EATON	800.0A	Interrupting 100.0	Phase
322	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
323			800.0A	Short Time 85.0	tr (I2t) 2
324					Isd 3 (2400A)
325					tsd (Flat) 0.05
326					Ii 6 (4800A)
327					Ground
328					Ig (In<1200A) 1 (800A)
329					tg (Flat) 0.2
330					ARMS (Maint)
331					Ir 1 (800A)
332					tr (I2t) 0.5
333					Isd 1.5 (1200A)
334					tsd (Flat) 0.05
335					Ii 2 (1600A)
336					
337	PD-MECH1-BUS A (2C):SWBD5	EATON	1600.0A	Interrupting 100.0	Phase
338	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
339			1600.0A	Short Time 85.0	tr (I2t) 1.3
340					Isd 3 (4800A)
341					tsd (Flat) 0.13
342					Ii 5 (8000A)
343					Ground
344					Ig (In>=1200A) 1 (1200A)
345					tg (Flat) 0.2
346					ARMS (Maint)
347					Ir 1 (1600A)
348					tr (I2t) 0.5
349					Isd 1.5 (2400A)
350					tsd (Flat) 0.05
351					Ii 2 (3200A)
352					
353	PD-MECH1-BUS A (2D): SWBD1	EATON	1600.0A	Interrupting 100.0	Phase
354	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
355			1600.0A	Short Time 85.0	tr (I2t) 1.3
356					Isd 3 (4800A)
357					tsd (Flat) 0.13
358					Ii 5 (8000A)
359					Ground
360					Ig (In>=1200A) 1 (1200A)
361					tg (Flat) 0.2
362					ARMS (Maint)
363					Ir 1 (1600A)
364					tr (I2t) 0.5
365					Isd 1.5 (2400A)
366					tsd (Flat) 0.05
367					Ii 2 (3200A)
368					
369	PD-MECH1-BUS A (3A):ATS-EL1	EATON	800.0A	Interrupting 100.0	Phase
370	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
371			800.0A	Short Time 85.0	tr (I2t) 0.5
372					Isd 1.5 (1200A)
373					tsd (Flat) 0.05

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
374					Ii 2 (1600A)
375					Ground
376					Ig (In<1200A) 1 (800A)
377					tg (Flat) 0.2
378					ARMS (Maint)
379					Ir 1 (800A)
380					tr (I2t) 0.5
381					Isd 1.5 (1200A)
382					tsd (Flat) 0.05
383					Ii 2 (1600A)
384					
385	PD-MECH1-BUS A (3B):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
386	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
387			1600.0A	Short Time 85.0	tr (I2t) 0.5
388					Isd 1.5 (2400A)
389					tsd (Flat) 0.05
390					Ii 2 (3200A)
391					Ground
392					Ig (In>=1200A) 1 (1200A)
393					tg (Flat) 0.2
394					ARMS (Maint)
395					Ir 1 (1600A)
396					tr (I2t) 0.5
397					Isd 1.5 (2400A)
398					tsd (Flat) 0.05
399					Ii 2 (3200A)
400					
401	PD-MECH1-BUS A (3C):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
402	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
403			1600.0A	Short Time 85.0	tr (I2t) 0.5
404					Isd 1.5 (2400A)
405					tsd (Flat) 0.05
406					Ii 2 (3200A)
407					Ground
408					Ig (In>=1200A) 1 (1200A)
409					tg (Flat) 0.2
410					ARMS (Maint)
411					Ir 1 (1600A)
412					tr (I2t) 0.5
413					Isd 1.5 (2400A)
414					tsd (Flat) 0.05
415					Ii 2 (3200A)
416					
417	PD-MECH1-BUS A (3D):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
418	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
419			1600.0A	Short Time 85.0	tr (I2t) 0.5
420					Isd 1.5 (2400A)
421					tsd (Flat) 0.05
422					Ii 2 (3200A)
423					Ground
424					Ig (In>=1200A) 1 (1200A)
425					tg (Flat) 0.2
426					ARMS (Maint)
427					Ir 1 (1600A)
428					tr (I2t) 0.5
429					Isd 1.5 (2400A)
430					tsd (Flat) 0.05
431					Ii 2 (3200A)
432					
433	PD-MECH1-BUS A-TIE	EATON	5000.0A	Interrupting 100.0	Phase
434	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
435			5000.0A		tr (I2t) 0.5

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
436					Isd 1.5 (7500A)
437					tsd (Flat) 0.2
438					Ii 4 (20000A)
439					Ground
440					Ig (In>=1200A) 1 (1200A)
441					tg (Flat) 0.2
442					ARMS (Maint)
443					Ir 1 (5000A)
444					tr (I2t) 0.5
445					Isd 1.5 (7500A)
446					tsd (Flat) 0.05
447					Ii 2 (10000A)
448					
449	PD-MECH1-BUS B (2A):SPARE	EATON	800.0A	Interrupting 100.0	Phase
450	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
451			800.0A	Short Time 85.0	tr (I2t) 0.5
452					Isd 1.5 (1200A)
453					tsd (Flat) 0.05
454					Ii 2 (1600A)
455					Ground
456					Ig (In<1200A) 1 (800A)
457					tg (Flat) 0.2
458					ARMS (Maint)
459					Ir 1 (800A)
460					tr (I2t) 0.5
461					Isd 1.5 (1200A)
462					tsd (Flat) 0.05
463					Ii 2 (1600A)
464					
465	PD-MECH1-BUS B (2B):ATS-GEN1	EATON	800.0A	Interrupting 100.0	Phase
466	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
467			800.0A	Short Time 85.0	tr (I2t) 0.5
468					Isd 1.5 (1200A)
469					tsd (Flat) 0.05
470					Ii 2 (1600A)
471					Ground
472					Ig (In<1200A) 1 (800A)
473					tg (Flat) 0.2
474					ARMS (Maint)
475					Ir 1 (800A)
476					tr (I2t) 0.5
477					Isd 1.5 (1200A)
478					tsd (Flat) 0.05
479					Ii 2 (1600A)
480					
481	PD-MECH1-BUS B (2C):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
482	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
483			1600.0A	Short Time 85.0	tr (I2t) 0.5
484					Isd 1.5 (2400A)
485					tsd (Flat) 0.05
486					Ii 2 (3200A)
487					Ground
488					Ig (In>=1200A) 1 (1200A)
489					tg (Flat) 0.2
490					ARMS (Maint)
491					Ir 1 (1600A)
492					tr (I2t) 0.5
493					Isd 1.5 (2400A)
494					tsd (Flat) 0.05
495					Ii 2 (3200A)
496					
497	PD-MECH1-BUS B (2D):SWBD7	EATON	1600.0A	Interrupting 100.0	Phase

Protective Device Settings

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
498	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
499			1600.0A	Short Time 85.0	tr (I2t) 1.3
500					Isd 3 (4800A)
501					tsd (Flat) 0.13
502					Ii 5 (8000A)
503					Ground
504					Ig (In>=1200A) 1 (1200A)
505					tg (Flat) 0.2
506					ARMS (Maint)
507					Ir 1 (1600A)
508					tr (I2t) 0.5
509					Isd 1.5 (2400A)
510					tsd (Flat) 0.05
511					Ii 2 (3200A)
512					
513	PD-MECH1-BUS B (3A):SPARE	EATON	800.0A	Interrupting 100.0	Phase
514	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
515			800.0A	Short Time 85.0	tr (I2t) 0.5
516					Isd 1.5 (1200A)
517					tsd (Flat) 0.05
518					Ii 2 (1600A)
519					Ground
520					Ig (In<1200A) 1 (800A)
521					tg (Flat) 0.2
522					ARMS (Maint)
523					Ir 1 (800A)
524					tr (I2t) 0.5
525					Isd 1.5 (1200A)
526					tsd (Flat) 0.05
527					Ii 2 (1600A)
528					
529	PD-MECH1-BUS B (3B):HRC5	EATON	800.0A	Interrupting 100.0	Phase
530	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
531			800.0A	Short Time 85.0	tr (I2t) 2
532					Isd 3 (2400A)
533					tsd (Flat) 0.05
534					Ii 6 (4800A)
535					Ground
536					Ig (In<1200A) 1 (800A)
537					tg (Flat) 0.2
538					ARMS (Maint)
539					Ir 1 (800A)
540					tr (I2t) 0.5
541					Isd 1.5 (1200A)
542					tsd (Flat) 0.05
543					Ii 2 (1600A)
544					
545	PD-MECH1-BUS B (3C):SWBD3	EATON	1600.0A	Interrupting 100.0	Phase
546	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
547			1600.0A	Short Time 85.0	tr (I2t) 1.3
548					Isd 3 (4800A)
549					tsd (Flat) 0.13
550					Ii 5 (8000A)
551					Ground
552					Ig (In>=1200A) 1 (1200A)
553					tg (Flat) 0.2
554					ARMS (Maint)
555					Ir 1 (1600A)
556					tr (I2t) 0.5
557					Isd 1.5 (2400A)
558					tsd (Flat) 0.05
559					Ii 2 (3200A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
560					
561	PD-MECH1-BUS B (3D)>FIRE PUMP1	EATON	2500.0A	Interrupting 100.0	Phase
562	Static Trip	Magnum PXR 25	2500.0A	Override 85.0	Ir 0.4 (1000A)
563			2500.0A	Short Time 85.0	tr (I2t) 3
564					Isd 4 (4000A)
565					tsd (Flat) 0.05
566					Ii 5 (12500A)
567					Ground
568					Ig (In>=1200A) 1 (1200A)
569					tg (Flat) 0.2
570					ARMS (maint)
571					Ir 1 (2500A)
572					tr (I2t) 0.5
573					Isd 1.5 (3750A)
574					tsd (Flat) 0.05
575					Ii 2 (5000A)
576					
577	PD-MECH1-BUS B-TIE	EATON	5000.0A	Interrupting 100.0	Phase
578	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
579			5000.0A		tr (I2t) 0.5
580					Isd 1.5 (7500A)
581					tsd (Flat) 0.2
582					Ii 4 (20000A)
583					Ground
584					Ig (In>=1200A) 1 (1200A)
585					tg (Flat) 0.2
586					ARMS (Maint)
587					Ir 1 (5000A)
588					tr (I2t) 0.5
589					Isd 1.5 (7500A)
590					tsd (Flat) 0.05
591					Ii 2 (10000A)
592					
593	PD-MECH2-BUS A (2A):HRC2	EATON	800.0A	Interrupting 100.0	Phase
594	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
595			800.0A	Short Time 85.0	tr (I2t) 2
596					Isd 3 (2400A)
597					tsd (Flat) 0.05
598					Ii 6 (4800A)
599					Ground
600					Ig (In<1200A) 1 (800A)
601					tg (Flat) 0.2
602					ARMS (Maint)
603					Ir 1 (800A)
604					tr (I2t) 0.5
605					Isd 1.5 (1200A)
606					tsd (Flat) 0.05
607					Ii 2 (1600A)
608					
609	PD-MECH2-BUS A (2B):SPARE	EATON	800.0A	Interrupting 100.0	Phase
610	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
611			800.0A	Short Time 85.0	tr (I2t) 0.5
612					Isd 1.5 (1200A)
613					tsd (Flat) 0.05
614					Ii 2 (1600A)
615					Ground
616					Ig (In<1200A) 1 (800A)
617					tg (Flat) 0.2
618					ARMS (Maint)
619					Ir 1 (800A)
620					tr (I2t) 0.5
621					Isd 1.5 (1200A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
622					tsd (Flat) 0.05
623					Ii 2 (1600A)
624					
625	PD-MECH2-BUS A (2C):SWBD6	EATON	1600.0A	Interrupting 100.0	Phase
626	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
627			1600.0A	Short Time 85.0	tr (I2t) 1.3
628					Isd 3 (4800A)
629					tsd (Flat) 0.13
630					Ii 5 (8000A)
631					Ground
632					Ig (In>=1200A) 1 (1200A)
633					tg (Flat) 0.2
634					ARMS (Maint)
635					Ir 1 (1600A)
636					tr (I2t) 0.5
637					Isd 1.5 (2400A)
638					tsd (Flat) 0.05
639					Ii 2 (3200A)
640					
641	PD-MECH2-BUS A (2D): SWBD2	EATON	1600.0A	Interrupting 100.0	Phase
642	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
643			1600.0A	Short Time 85.0	tr (I2t) 1.3
644					Isd 3 (4800A)
645					tsd (Flat) 0.13
646					Ii 5 (8000A)
647					Ground
648					Ig (In>=1200A) 1 (1200A)
649					tg (Flat) 0.2
650					ARMS (Maint)
651					Ir 1 (1600A)
652					tr (I2t) 0.5
653					Isd 1.5 (2400A)
654					tsd (Flat) 0.05
655					Ii 2 (3200A)
656					
657	PD-MECH2-BUS A (3A):ATS-LS1	EATON	800.0A	Interrupting 100.0	Phase
658	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
659			800.0A	Short Time 85.0	tr (I2t) 0.5
660					Isd 1.5 (1200A)
661					tsd (Flat) 0.05
662					Ii 2 (1600A)
663					Ground
664					Ig (In<1200A) 1 (800A)
665					tg (Flat) 0.2
666					ARMS (Maint)
667					Ir 1 (800A)
668					tr (I2t) 0.5
669					Isd 1.5 (1200A)
670					tsd (Flat) 0.05
671					Ii 2 (1600A)
672					
673	PD-MECH2-BUS A (3B):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
674	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
675			1600.0A	Short Time 85.0	tr (I2t) 0.5
676					Isd 1.5 (2400A)
677					tsd (Flat) 0.05
678					Ii 2 (3200A)
679					Ground
680					Ig (In>=1200A) 1 (1200A)
681					tg (Flat) 0.2
682					ARMS (Maint)
683					Ir 1 (1600A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
684					tr (I2t) 0.5
685					Isd 1.5 (2400A)
686					tsd (Flat) 0.05
687					Ii 2 (3200A)
688					
689	PD-MECH2-BUS A (3C):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
690	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
691			1600.0A	Short Time 85.0	tr (I2t) 0.5
692					Isd 1.5 (2400A)
693					tsd (Flat) 0.05
694					Ii 2 (3200A)
695					Ground
696					Ig (In>=1200A) 1 (1200A)
697					tg (Flat) 0.2
698					ARMS (Maint)
699					Ir 1 (1600A)
700					tr (I2t) 0.5
701					Isd 1.5 (2400A)
702					tsd (Flat) 0.05
703					Ii 2 (3200A)
704					
705	PD-MECH2-BUS A (3D):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
706	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
707			1600.0A	Short Time 85.0	tr (I2t) 0.5
708					Isd 1.5 (2400A)
709					tsd (Flat) 0.05
710					Ii 2 (3200A)
711					Ground
712					Ig (In>=1200A) 1 (1200A)
713					tg (Flat) 0.2
714					ARMS (Maint)
715					Ir 1 (1600A)
716					tr (I2t) 0.5
717					Isd 1.5 (2400A)
718					tsd (Flat) 0.05
719					Ii 2 (3200A)
720					
721	PD-MECH2-BUS A-TIE	EATON	5000.0A	Interrupting 100.0	Phase
722	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
723			5000.0A		tr (I2t) 0.5
724					Isd 1.5 (7500A)
725					tsd (Flat) 0.2
726					Ii 4 (20000A)
727					Ground
728					Ig (In>=1200A) 1 (1200A)
729					tg (Flat) 0.2
730					ARMS (Maint)
731					Ir 1 (5000A)
732					tr (I2t) 0.5
733					Isd 1.5 (7500A)
734					tsd (Flat) 0.05
735					Ii 2 (10000A)
736					
737	PD-MECH2-BUS B (2A):SPARE	EATON	800.0A	Interrupting 100.0	Phase
738	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
739			800.0A	Short Time 85.0	tr (I2t) 0.5
740					Isd 1.5 (1200A)
741					tsd (Flat) 0.05
742					Ii 2 (1600A)
743					Ground
744					Ig (In<1200A) 1 (800A)
745					tg (Flat) 0.2

Protective Device Settings

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
746					ARMS (Maint)
747					Ir 1 (800A)
748					tr (I2t) 0.5
749					Isd 1.5 (1200A)
750					tsd (Flat) 0.05
751					Ii 2 (1600A)
752					
753	PD-MECH2-BUS B (2B):ATS EQ1	EATON	800.0A	Interrupting 100.0	Phase
754	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
755			800.0A	Short Time 85.0	tr (I2t) 0.5
756					Isd 1.5 (1200A)
757					tsd (Flat) 0.05
758					Ii 2 (1600A)
759					Ground
760					Ig (In<1200A) 1 (800A)
761					tg (Flat) 0.2
762					ARMS (Maint)
763					Ir 1 (800A)
764					tr (I2t) 0.5
765					Isd 1.5 (1200A)
766					tsd (Flat) 0.05
767					Ii 2 (1600A)
768					
769	PD-MECH2-BUS B (2C):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
770	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
771			1600.0A	Short Time 85.0	tr (I2t) 0.5
772					Isd 1.5 (2400A)
773					tsd (Flat) 0.05
774					Ii 2 (3200A)
775					Ground
776					Ig (In>=1200A) 1 (1200A)
777					tg (Flat) 0.2
778					ARMS (Maint)
779					Ir 1 (1600A)
780					tr (I2t) 0.5
781					Isd 1.5 (2400A)
782					tsd (Flat) 0.05
783					Ii 2 (3200A)
784					
785	PD-MECH2-BUS B (2D):SPARE	EATON	1600.0A	Interrupting 100.0	Phase
786	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
787			1600.0A	Short Time 85.0	tr (I2t) 0.5
788					Isd 1.5 (2400A)
789					tsd (Flat) 0.05
790					Ii 2 (3200A)
791					Ground
792					Ig (In>=1200A) 1 (1200A)
793					tg (Flat) 0.2
794					ARMS (Maint)
795					Ir 1 (1600A)
796					tr (I2t) 0.5
797					Isd 1.5 (2400A)
798					tsd (Flat) 0.05
799					Ii 2 (3200A)
800					
801	PD-MECH2-BUS B (3A):SPARE	EATON	800.0A	Interrupting 100.0	Phase
802	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
803			800.0A	Short Time 85.0	tr (I2t) 0.5
804					Isd 1.5 (1200A)
805					tsd (Flat) 0.05
806					Ii 2 (1600A)
807					Ground

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
808					Ig (In<1200A) 1 (800A)
809					tg (Flat) 0.2
810					ARMS (Maint)
811					Ir 1 (800A)
812					tr (I2t) 0.5
813					Isd 1.5 (1200A)
814					tsd (Flat) 0.05
815					Ii 2 (1600A)
816					
817	PD-MECH2-BUS B (3B):HRC4	EATON	800.0A	Interrupting 100.0	Phase
818	Static Trip	Magnum PXR 25	800.0A	Override 85.0	Ir 1 (800A)
819			800.0A	Short Time 85.0	tr (I2t) 2
820					Isd 3 (2400A)
821					tsd (Flat) 0.05
822					Ii 6 (4800A)
823					Ground
824					Ig (In<1200A) 1 (800A)
825					tg (Flat) 0.2
826					ARMS (Maint)
827					Ir 1 (800A)
828					tr (I2t) 0.5
829					Isd 1.5 (1200A)
830					tsd (Flat) 0.05
831					Ii 2 (1600A)
832					
833	PD-MECH2-BUS B (3C):SWBD4	EATON	1600.0A	Interrupting 100.0	Phase
834	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
835			1600.0A	Short Time 85.0	tr (I2t) 1.3
836					Isd 3 (4800A)
837					tsd (Flat) 0.13
838					Ii 5 (8000A)
839					Ground
840					Ig (In>=1200A) 1 (1200A)
841					tg (Flat) 0.2
842					ARMS (Maint)
843					Ir 1 (1600A)
844					tr (I2t) 0.5
845					Isd 1.5 (2400A)
846					tsd (Flat) 0.05
847					Ii 2 (3200A)
848					
849	PD-MECH2-BUS B (3D)>FIRE PUMP2	EATON	2500.0A	Interrupting 100.0	Phase
850	Static Trip	Magnum PXR 25	2500.0A	Override 85.0	Ir 1 (2500A)
851			2500.0A	Short Time 85.0	tr (I2t) 0.5
852					Isd 1.5 (3750A)
853					tsd (Flat) 0.05
854					Ii 2 (5000A)
855					Ground
856					Ig (In>=1200A) 1 (1200A)
857					tg (Flat) 0.2
858					ARMS (maint)
859					Ir 1 (2500A)
860					tr (I2t) 0.5
861					Isd 1.5 (3750A)
862					tsd (Flat) 0.05
863					Ii 2 (5000A)
864					
865	PD-MECH2-BUS B-TIE	EATON	5000.0A	Interrupting 100.0	Phase
866	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
867			5000.0A		tr (I2t) 0.5
868					Isd 1.5 (7500A)
869					tsd (Flat) 0.2

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
870					Ii 4 (20000A)
871					Ground
872					Ig (In>=1200A) 1 (1200A)
873					tg (Flat) 0.2
874					ARMS (Maint)
875					Ir 1 (5000A)
876					tr (I2t) 0.5
877					Isd 1.5 (7500A)
878					tsd (Flat) 0.05
879					Ii 2 (10000A)
880					
881	PD-SPD-CH1-BUS A	0.0A	Interrupting 0.0		
882	Static Trip				
883					
884	PD-SPD-CH2-BUS A	0.0A	Interrupting 0.0		
885	Static Trip				
886					
887	PD-SPD-ESS-CUP	0.0A	Interrupting 0.0		
888	Static Trip				
889					
890	PD-SPD-USS-CH1-BUS B	0.0A	Interrupting 0.0		
891	Static Trip				
892					
893	PD-SPD-USS-CH2-BUS B	0.0A	Interrupting 0.0		
894	Static Trip				
895					
896	PD-SPD-USS-MECH1-BUS B	0.0A	Interrupting 0.0		
897	Static Trip				
898					
899	PD-SPD-USS-MECH2-BUS A	0.0A	Interrupting 0.0		
900	Static Trip				
901					
902	PD-SPD-USS-MECH2-BUS B	0.0A	Interrupting 0.0		
903	Static Trip				
904					
905	PD-SWBD1#1:CT1	EATON	250.0A	Interrupting 65.0	Ir G (225A)
906	Static Trip	LG Frame, 310+	250.0A		tr 7
907			250.0A		Isd 6 (1350A)
908					tsd Fixed (I^s T On)
909					Ii OR Fixed (3000A)
910					
911	PD-SWBD1#2:CT3	EATON	250.0A	Interrupting 65.0	Ir G (225A)
912	Static Trip	LG Frame, 310+	250.0A		tr 7
913			250.0A		Isd 6 (1350A)
914					tsd Fixed (I^s T On)
915					Ii OR Fixed (3000A)
916					
917	PD-SWBD1#3:CT5	EATON	250.0A	Interrupting 65.0	Ir G (225A)
918	Static Trip	LG Frame, 310+	250.0A		tr 7
919			250.0A		Isd 6 (1350A)
920					tsd Fixed (I^s T On)
921					Ii OR Fixed (3000A)
922					
923	PD-SWBD1#4:CTP1	EATON	400.0A	Interrupting 65.0	Ir H (400A)
924	Static Trip	LG Frame, 310+	400.0A		tr 7
925			400.0A		Isd 7 (2800A)
926					tsd Fixed (I^s T On)
927					Ii OR Fixed (4800A)
928					
929	PD-SWBD1#5:CC-SS-FLTR-1	EATON	35.0A	Interrupting 65.0	480V
930	Thermal Magnetic	PD-2, PDF2_M	35.0A		
931			35.0A		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
932					
933	PD-SWBD1#5:CTP3	EATON	400.0A	Interrupting 65.0	Ir H (400A)
934	Static Trip	LG Frame, 310+	400.0A		tr 7
935			400.0A		Isd 7 (2800A)
936					tsd Fixed (I^s T On)
937					Ii OR Fixed (4800A)
938					
939	PD-SWBD1#6:CT-BASIN-SWP-FLTR-1	EATON	45.0A	Interrupting 65.0	480V
940	Thermal Magnetic	PD-2, PDF2_M	45.0A		
941			45.0A		
942					
943	PD-SWBD1#6:CTP5	EATON	400.0A	Interrupting 65.0	Ir H (400A)
944	Static Trip	LG Frame, 310+	400.0A		tr 7
945			400.0A		Isd 7 (2800A)
946					tsd Fixed (I^s T On)
947					Ii OR Fixed (4800A)
948					
949	PD-SWBD1-MAIN	EATON	1600.0A	Interrupting 100.0	Phase
950	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
951			1600.0A	Short Time 85.0	tr (I2t) 1
952					Isd 2.7 (4320A)
953					tsd (Flat) 0.1
954					Ii 5 (8000A)
955					Ground
956					Ig (In>=1200A) 1 (1200A)
957					tg (Flat) 0.2
958					ARMS (Maint)
959					Ir 1 (1600A)
960					tr (I2t) 0.5
961					Isd 1.5 (2400A)
962					tsd (Flat) 0.05
963					Ii 2 (3200A)
964					
965	PD-SWBD2#1:CTF2	EATON	250.0A	Interrupting 65.0	Ir G (225A)
966	Static Trip	LG Frame, 310+	250.0A		tr 7
967			250.0A		Isd 6 (1350A)
968					tsd Fixed (I^s T On)
969					Ii OR Fixed (3000A)
970					
971	PD-SWBD2#2:CTF4	EATON	250.0A	Interrupting 65.0	Ir G (225A)
972	Static Trip	LG Frame, 310+	250.0A		tr 7
973			250.0A		Isd 6 (1350A)
974					tsd Fixed (I^s T On)
975					Ii OR Fixed (3000A)
976					
977	PD-SWBD2#3:CTF6	EATON	250.0A	Interrupting 65.0	Ir G (225A)
978	Static Trip	LG Frame, 310+	250.0A		tr 7
979			250.0A		Isd 6 (1350A)
980					tsd Fixed (I^s T On)
981					Ii OR Fixed (3000A)
982					
983	PD-SWBD2#4:CTP-2	EATON	400.0A	Interrupting 65.0	Ir H (400A)
984	Static Trip	LG Frame, 310+	400.0A		tr 7
985			400.0A		Isd 7 (2800A)
986					tsd Fixed (I^s T On)
987					Ii OR Fixed (4800A)
988					
989	PD-SWBD2#5:CTP-4	EATON	400.0A	Interrupting 65.0	Ir H (400A)
990	Static Trip	LG Frame, 310+	400.0A		tr 7
991			400.0A		Isd 7 (2800A)
992					tsd Fixed (I^s T On)
993					Ii OR Fixed (4800A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
994					
995	PD-SWBD2#6:CTP-6	EATON	400.0A	Interrupting 65.0	Ir H (400A)
996	Static Trip	LG Frame, 310+	400.0A		tr 7
997			400.0A		Isd 7 (2800A)
998					tsd Fixed (I^s T On)
999					Ii OR Fixed (4800A)
1000					
1001	PD-SWBD2#7:SPARE	SIEMENS	150.0A	Interrupting 65.0	LTPU (Ir) 125 (125A)
1002	Static Trip	3VA6, ETU 350	150.0A		LTD (tld) 5 (I^s T On)
1003			150.0A		STPU (Isd) 6 (750A)
1004					STD (tsd) 0.02 (I^s T On)
1005					INST (Ii) Fixed (1500A)
1006					
1007	PD-SWBD2-MAIN	EATON	1600.0A	Interrupting 100.0	Phase
1008	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
1009			1600.0A	Short Time 85.0	tr (I2t) 1
1010					Isd 3 (4800A)
1011					tsd (Flat) 0.1
1012					Ii 5 (8000A)
1013					Ground
1014					Ig (In>=1200A) 1 (1200A)
1015					tg (Flat) 0.2
1016					ARMS (Maint)
1017					Ir 1 (1600A)
1018					tr (I2t) 0.5
1019					Isd 1.5 (2400A)
1020					tsd (Flat) 0.05
1021					Ii 2 (3200A)
1022					
1023	PD-SWBD3#1:CHWP-1	EATON	400.0A	Interrupting 65.0	Ir H (400A)
1024	Static Trip	LG Frame, 310+	400.0A		tr 7
1025			400.0A		Isd 7 (2800A)
1026					tsd Fixed (I^s T On)
1027					Ii OR Fixed (4800A)
1028					
1029	PD-SWBD3#1:CHWP-2	EATON	400.0A	Interrupting 65.0	Ir H (400A)
1030	Static Trip	LG Frame, 310+	400.0A		tr 7
1031			400.0A		Isd 7 (2800A)
1032					tsd Fixed (I^s T On)
1033					Ii OR Fixed (4800A)
1034					
1035	PD-SWBD3#2:CHWP-3	EATON	400.0A	Interrupting 65.0	Ir H (400A)
1036	Static Trip	LG Frame, 310+	400.0A		tr 7
1037			400.0A		Isd 7 (2800A)
1038					tsd Fixed (I^s T On)
1039					Ii OR Fixed (4800A)
1040					
1041	PD-SWBD3#2:CHWP-4	EATON	400.0A	Interrupting 65.0	Ir H (400A)
1042	Static Trip	LG Frame, 310+	400.0A		tr 7
1043			400.0A		Isd 7 (2800A)
1044					tsd Fixed (I^s T On)
1045					Ii OR Fixed (4800A)
1046					
1047	PD-SWBD3#3:CHWP-5	EATON	400.0A	Interrupting 65.0	Ir H (400A)
1048	Static Trip	LG Frame, 310+	400.0A		tr 7
1049			400.0A		Isd 7 (2800A)
1050					tsd Fixed (I^s T On)
1051					Ii OR Fixed (4800A)
1052					
1053	PD-SWBD3#3:CHWP-6	EATON	400.0A	Interrupting 65.0	Ir H (400A)
1054	Static Trip	LG Frame, 310+	400.0A		tr 7
1055			400.0A		Isd 7 (2800A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1056					tsd Fixed (I^s T On)
1057					Ii OR Fixed (4800A)
1058					
1059	PD-SWBD3#3:CHWP-7	EATON	400.0A	Interrupting 65.0	Ir H (400A)
1060	Static Trip	LG Frame, 310+	400.0A		tr 7
1061			400.0A		Isd 7 (2800A)
1062					tsd Fixed (I^s T On)
1063					Ii OR Fixed (4800A)
1064					
1065	PD-SWBD3#4:HRHHWP-1	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
1066	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
1067			125.0A		STPU (2 - 12 x Ir) 2 (250A)
1068					INST OR Fixed (3000A)
1069					
1070	PD-SWBD3#5:HRHHWP-3	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
1071	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
1072			125.0A		STPU (2 - 12 x Ir) 2 (250A)
1073					INST OR Fixed (3000A)
1074					
1075	PD-SWBD3#6:HRCWP-1	EATON	30.0A	Interrupting 65.0	480V
1076	Thermal Magnetic	PD-2, PDF2_M	30.0A		
1077			30.0A		
1078					
1079	PD-SWBD3#7:HRCWP-3	EATON	30.0A	Interrupting 65.0	480V
1080	Thermal Magnetic	PD-2, PDF2_M	30.0A		
1081			30.0A		
1082					
1083	PD-SWBD3-MAIN	EATON	1600.0A	Interrupting 100.0	Phase
1084	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
1085			1600.0A	Short Time 85.0	tr (I2t) 1
1086					Isd 3 (4800A)
1087					tsd (Flat) 0.1
1088					Ii 5 (8000A)
1089					Ground
1090					Ig (In>=1200A) 1 (1200A)
1091					tg (Flat) 0.2
1092					ARMS (Maint)
1093					Ir 1 (1600A)
1094					tr (I2t) 0.5
1095					Isd 1.5 (2400A)
1096					tsd (Flat) 0.05
1097					Ii 2 (3200A)
1098					
1099	PD-SWBD3-MAIN0	EATON	1600.0A	Interrupting 100.0	Phase
1100	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
1101			1600.0A	Short Time 85.0	tr (I2t) 1
1102					Isd 3 (4800A)
1103					tsd (Flat) 0.1
1104					Ii 5 (8000A)
1105					Ground
1106					Ig (In>=1200A) 1 (1200A)
1107					tg (Flat) 0.2
1108					ARMS (Maint)
1109					Ir 1 (1600A)
1110					tr (I2t) 0.5
1111					Isd 1.5 (2400A)
1112					tsd (Flat) 0.05
1113					Ii 2 (3200A)
1114					
1115	PD-SWBD4#4:HRC CHWP2	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
1116	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
1117			125.0A		STPU (2 - 12 x Ir) 2 (250A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1118					INST OR Fixed (3000A)
1119					
1120	PD-SWBD4#5:HRC CHWP4	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
1121	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
1122			125.0A		STPU (2 - 12 x Ir) 2 (250A)
1123					INST OR Fixed (3000A)
1124					
1125	PD-SWBD4#6:HRC HHWP2	EATON	30.0A	Interrupting 65.0	480V
1126	Thermal Magnetic	PD-2, PDF2_M	30.0A		
1127			30.0A		
1128					
1129	PD-SWBD4#7:HRC HHWP4	EATON	45.0A	Interrupting 65.0	480V
1130	Thermal Magnetic	PD-2, PDF2_M	45.0A		
1131			45.0A		
1132					
1133	PD-SWBD4-MAIN	EATON	1600.0A	Interrupting 100.0	Phase
1134	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
1135			1600.0A	Short Time 85.0	tr (I2t) 1
1136					Isd 3 (4800A)
1137					tsd (Flat) 0.1
1138					Ii 5 (8000A)
1139					Ground
1140					Ig (In>=1200A) 1 (1200A)
1141					tg (Flat) 0.2
1142					ARMS (Maint)
1143					Ir 1 (1600A)
1144					tr (I2t) 0.5
1145					Isd 1.5 (2400A)
1146					tsd (Flat) 0.05
1147					Ii 2 (3200A)
1148					
1149	PD-SWBD5#14:DA-1	EATON	125.0A	Interrupting 65.0	LTPU (A-H) H (125) (125A)
1150	Static Trip	K Frame Series C, Digitrip 310+	125.0A		LTD (2 - 24s) 2
1151			125.0A		STPU (2 - 12 x Ir) 2 (250A)
1152					INST OR Fixed (3000A)
1153					
1154	PD-SWBD5#16:1NH1	EATON	250.0A	Interrupting 65.0	Ir G (225A)
1155	Static Trip	LG Frame, 310+	250.0A		tr 7
1156			250.0A		Isd 6 (1350A)
1157					tsd Fixed (I^s T On)
1158					Ii OR Fixed (3000A)
1159					
1160	PD-SWBD5#1:HHW-FILTER	EATON	45.0A	Interrupting 65.0	480V
1161	Thermal Magnetic	PD-2, PDF2_M	45.0A		
1162			45.0A		
1163					
1164	PD-SWBD5#2:HHWP-1	EATON	400.0A	Interrupting 65.0	Ir G (350A)
1165	Static Trip	LG Frame, 310+	400.0A		tr 7
1166			400.0A		Isd 7 (2450A)
1167					tsd Fixed (I^s T On)
1168					Ii OR Fixed (4800A)
1169					
1170	PD-SWBD5#2:HHWP-2	EATON	400.0A	Interrupting 65.0	Ir G (350A)
1171	Static Trip	LG Frame, 310+	400.0A		tr 7
1172			400.0A		Isd 7 (2450A)
1173					tsd Fixed (I^s T On)
1174					Ii OR Fixed (4800A)
1175					
1176	PD-SWBD5#3:HHWP-4	EATON	400.0A	Interrupting 65.0	Ir G (350A)
1177	Static Trip	LG Frame, 310+	400.0A		tr 7
1178			400.0A		Isd 7 (2450A)
1179					tsd Fixed (I^s T On)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1180					Ii OR Fixed (4800A)
1181					
1182	PD-SWBD5#3:HHWP3	EATON	400.0A	Interrupting 65.0	Ir G (350A)
1183	Static Trip	LG Frame, 310+	400.0A		tr 7
1184			400.0A		Isd 7 (2450A)
1185					tsd Fixed (I^s T On)
1186					Ii OR Fixed (4800A)
1187					
1188	PD-SWBD5#4:HHWP-6	EATON	400.0A	Interrupting 65.0	Ir G (350A)
1189	Static Trip	LG Frame, 310+	400.0A		tr 7
1190			400.0A		Isd 7 (2450A)
1191					tsd Fixed (I^s T On)
1192					Ii OR Fixed (4800A)
1193					
1194	PD-SWBD5#4:HHWP5	EATON	400.0A	Interrupting 65.0	Ir G (350A)
1195	Static Trip	LG Frame, 310+	400.0A		tr 7
1196			400.0A		Isd 7 (2450A)
1197					tsd Fixed (I^s T On)
1198					Ii OR Fixed (4800A)
1199					
1200	PD-SWBD5#5:SB-1	EATON	100.0A	Interrupting 65.0	Ir G (90A)
1201	Static Trip	JG-Frame, 310+	100.0A		tr 2
1202			100.0A		Isd 2 (180A)
1203					tsd Fixed (I^s T On)
1204					Ii OR Fixed (1400A)
1205					
1206	PD-SWBD5#5:SB-2	EATON	100.0A	Interrupting 65.0	Ir G (90A)
1207	Static Trip	JG-Frame, 310+	100.0A		tr 2
1208			100.0A		Isd 2 (180A)
1209					tsd Fixed (I^s T On)
1210					Ii OR Fixed (1400A)
1211					
1212	PD-SWBD5#6:SB-3	EATON	100.0A	Interrupting 65.0	Ir G (90A)
1213	Static Trip	JG-Frame, 310+	100.0A		tr 2
1214			100.0A		Isd 2 (180A)
1215					tsd Fixed (I^s T On)
1216					Ii OR Fixed (1400A)
1217					
1218	PD-SWBD5-MAIN	EATON	1600.0A	Interrupting 100.0	Phase
1219	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)
1220			1600.0A	Short Time 85.0	tr (I2t) 1
1221					Isd 3 (4800A)
1222					tsd (Flat) 0.1
1223					Ii 5 (8000A)
1224					Ground
1225					Ig (In>=1200A) 1 (1200A)
1226					tg (Flat) 0.2
1227					ARMS (Maint)
1228					Ir 1 (1600A)
1229					tr (I2t) 0.5
1230					Isd 1.5 (2400A)
1231					tsd (Flat) 0.05
1232					Ii 2 (3200A)
1233					
1234	PD-SWBD6#13:1NH2	EATON	250.0A	Interrupting 65.0	Ir G (225A)
1235	Static Trip	LG Frame, 310+	250.0A		tr 7
1236			250.0A		Isd 6 (1350A)
1237					tsd Fixed (I^s T On)
1238					Ii OR Fixed (3000A)
1239					
1240	PD-SWBD6-MAIN	EATON	1600.0A	Interrupting 100.0	Phase
1241	Static Trip	Magnum PXR 25	1600.0A	Override 85.0	Ir 1 (1600A)

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1242			1600.0A	Short Time 85.0	tr (I2t) 1
1243					Isd 3 (4800A)
1244					tsd (Flat) 0.1
1245					Ii 5 (8000A)
1246					Ground
1247					Ig (In>=1200A) 1 (1200A)
1248					tg (Flat) 0.2
1249					ARMS (Maint)
1250					Ir 1 (1600A)
1251					tr (I2t) 0.5
1252					Isd 1.5 (2400A)
1253					tsd (Flat) 0.05
1254					Ii 2 (3200A)
1255					
1256	PD-SWBD7#4:1NH3	EATON	250.0A	Interrupting 65.0	Ir G (225A)
1257	Static Trip	LG Frame, 310+	250.0A		tr 7
1258			250.0A		Isd 6 (1350A)
1259					tsd Fixed (I^s T On)
1260					Ii OR Fixed (3000A)
1261					
1262	PD-SWBD7#5:1NH4	EATON	250.0A	Interrupting 65.0	Ir G (225A)
1263	Static Trip	LG Frame, 310+	250.0A		tr 7
1264			250.0A		Isd 6 (1350A)
1265					tsd Fixed (I^s T On)
1266					Ii OR Fixed (3000A)
1267					
1268	PD-SWBD7#6:2NH1	EATON	250.0A	Interrupting 65.0	Ir G (225A)
1269	Static Trip	LG Frame, 310+	250.0A		tr 7
1270			250.0A		Isd 6 (1350A)
1271					tsd Fixed (I^s T On)
1272					Ii OR Fixed (3000A)
1273					
1274	PD-SWBD7#8:2NH2	EATON	250.0A	Interrupting 65.0	Ir G (225A)
1275	Static Trip	LG Frame, 310+	250.0A		tr 7
1276			250.0A		Isd 6 (1350A)
1277					tsd Fixed (I^s T On)
1278					Ii OR Fixed (3000A)
1279					
1280	PD-SWBD7#9:DBP-1	EATON	100.0A	Interrupting 65.0	Ir H (100A)
1281	Static Trip	JG-Frame, 310+	100.0A		tr 2
1282			100.0A		Isd 2 (200A)
1283					tsd Fixed (I^s T On)
1284					Ii OR Fixed (1400A)
1285					
1286	PD-USS-MECH1-BUS A	0.0A	Interrupting 0.0		
1287	Static Trip				
1288					
1289	PD-USS-MECH1-BUS A-MAIN	EATON	5000.0A	Interrupting 100.0	Phase
1290	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
1291			5000.0A		tr (I2t) 0.5
1292					Isd 1.5 (7500A)
1293					tsd (Flat) 0.2
1294					Ii 4 (20000A)
1295					Ground
1296					Ig (In>=1200A) 1 (1200A)
1297					tg (Flat) 0.2
1298					ARMS (Maint)
1299					Ir 1 (5000A)
1300					tr (I2t) 0.5
1301					Isd 1.5 (7500A)
1302					tsd (Flat) 0.05
1303					Ii 2 (10000A)

Protective Device Settings

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1304					
1305	PD-USS-MECH1-BUS B-MAIN	EATON	5000.0A	Interrupting 100.0	Phase
1306	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
1307			5000.0A		tr (I2t) 0.5
1308					Isd 1.5 (7500A)
1309					tsd (Flat) 0.2
1310					Ii 4 (20000A)
1311					Ground
1312					Ig (In>=1200A) 1 (1200A)
1313					tg (Flat) 0.2
1314					ARMS (Maint)
1315					Ir 1 (5000A)
1316					tr (I2t) 0.5
1317					Isd 1.5 (7500A)
1318					tsd (Flat) 0.05
1319					Ii 2 (10000A)
1320					
1321	PD-USS-MECH2-BUS A-MAIN	EATON	5000.0A	Interrupting 100.0	Phase
1322	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
1323			5000.0A		tr (I2t) 0.5
1324					Isd 1.5 (7500A)
1325					tsd (Flat) 0.2
1326					Ii 4 (20000A)
1327					Ground
1328					Ig (In>=1200A) 1 (1200A)
1329					tg (Flat) 0.2
1330					ARMS (Maint)
1331					Ir 1 (5000A)
1332					tr (I2t) 0.5
1333					Isd 1.5 (7500A)
1334					tsd (Flat) 0.05
1335					Ii 2 (10000A)
1336					
1337	PD-USS-MECH2-BUS B-MAIN	EATON	5000.0A	Interrupting 100.0	Phase
1338	Static Trip	Magnum PXR 25	5000.0A	Short Time 100.0	Ir 1 (5000A)
1339			5000.0A		tr (I2t) 0.5
1340					Isd 1.5 (7500A)
1341					tsd (Flat) 0.2
1342					Ii 4 (20000A)
1343					Ground
1344					Ig (In>=1200A) 1 (1200A)
1345					tg (Flat) 0.2
1346					ARMS (Maint)
1347					Ir 1 (5000A)
1348					tr (I2t) 0.5
1349					Isd 1.5 (7500A)
1350					tsd (Flat) 0.05
1351					Ii 2 (10000A)
1352					
1353	PD-VFD-CH#1	0.0A	Interrupting 0.0		
1354	Static Trip				
1355					
1356	PD-VFD-CH#2	0.0A	Interrupting 0.0		
1357	Static Trip				
1358					
1359	PD-VFD-CH#3	0.0A	Interrupting 0.0		
1360	Static Trip				
1361					
1362	PD-VFD-CH#4	0.0A	Interrupting 0.0		
1363	Static Trip				
1364					
1365	PD-VFD-CH#5	0.0A	Interrupting 0.0		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1366	Static Trip				
1367					
1368	PD-VFD-CH#6	0.0A	Interrupting 0.0		
1369	Static Trip				
1370					
1371	PD-VFD-HRC1	0.0A	Interrupting 0.0		
1372	Static Trip				
1373					
1374	PD-VFD-HRC2	0.0A	Interrupting 0.0		
1375	Static Trip				
1376					
1377	PD-VFD-HRC3	0.0A	Interrupting 0.0		
1378	Static Trip				
1379					
1380	PD-VFD-HRC4	0.0A	Interrupting 0.0		
1381	Static Trip				
1382					
1383	PD-VFD-HRC5	0.0A	Interrupting 0.0		
1384	Static Trip				
1385					
1386	**HV/MV without Trip-Unit**				
1387	Name/Type	Description	SC Ratings(kA)	Settings	
1388	PD-BUS-TIE	EATON	Interrupting 40.0		
1389		VCP-W			
1390					
1391	PD-CH1-BUS A (1):CH#1	EATON/CUTLER-HAMMER	Interrupting 63.0		
1392		VCP-WC			
1393					
1394	PD-CH1-BUS A (2):CH#2	EATON/CUTLER-HAMMER	Interrupting 63.0		
1395		VCP-WC			
1396					
1397	PD-CH1-BUS A-TIE	EATON/CUTLER-HAMMER	Interrupting 63.0		
1398		VCP-W			
1399					
1400	PD-CH1-BUS B (1):CH#5	EATON/CUTLER-HAMMER	Interrupting 63.0		
1401		VCP-WC			
1402					
1403	PD-CH1-BUS B (2):SPARE	EATON/CUTLER-HAMMER	Interrupting 63.0		
1404		VCP-WC			
1405					
1406	PD-CH1-BUS B-TIE	EATON/CUTLER-HAMMER	Interrupting 63.0		
1407		VCP-W			
1408					
1409	PD-CH2-BUS A (1):CH#2	EATON/CUTLER-HAMMER	Interrupting 63.0		
1410		VCP-WC			
1411					
1412	PD-CH2-BUS A (2):CH#4	EATON/CUTLER-HAMMER	Interrupting 63.0		
1413		VCP-WC			
1414					
1415	PD-CH2-BUS A-TIE	EATON/CUTLER-HAMMER	Interrupting 63.0		
1416		VCP-W			
1417					
1418	PD-CH2-BUS B (1):CH#6	EATON/CUTLER-HAMMER	Interrupting 63.0		
1419		VCP-WC			
1420					
1421	PD-CH2-BUS B (2):SPARE	EATON/CUTLER-HAMMER	Interrupting 63.0		
1422		VCP-WC			
1423					
1424	PD-CH2-BUS B-TIE	EATON/CUTLER-HAMMER	Interrupting 63.0		
1425		VCP-W			
1426					
1427	PD-FDR1-GEN BUS A	SQUARE D	Interrupting 40.0		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1428		VR			
1429					
1430	PD-FDR1-GEN BUS B	SQUARE D	Interrupting 40.0		
1431		VR			
1432					
1433	PD-FDR1-MSS-BUS A	EATON	Interrupting 40.0		
1434		VCP-W			
1435					
1436	PD-FDR10-GEN BUS A	SQUARE D	Interrupting 40.0		
1437		VR			
1438					
1439	PD-FDR10-GEN BUS B	SQUARE D	Interrupting 40.0		
1440		VR			
1441					
1442	PD-FDR10-MSS-BUS A	EATON	Interrupting 40.0		
1443		VCP-W			
1444					
1445	PD-FDR11-MSS-BUS B	EATON	Interrupting 40.0		
1446		VCP-W			
1447					
1448	PD-FDR12-MSS-BUS B	EATON	Interrupting 40.0		
1449		VCP-W			
1450					
1451	PD-FDR13-MSS-BUS B	EATON	Interrupting 40.0		
1452		VCP-W			
1453					
1454	PD-FDR14-MSS-BUS B	EATON	Interrupting 40.0		
1455		VCP-W			
1456					
1457	PD-FDR15-MSS-BUS B	EATON	Interrupting 40.0		
1458		VCP-W			
1459					
1460	PD-FDR16-MSS-BUS B	EATON	Interrupting 40.0		
1461		VCP-W			
1462					
1463	PD-FDR17-MSS-BUS B	EATON	Interrupting 40.0		
1464		VCP-W			
1465					
1466	PD-FDR18-MSS-BUS B	EATON	Interrupting 40.0		
1467		VCP-W			
1468					
1469	PD-FDR19-MSS-BUS B	EATON	Interrupting 40.0		
1470		VCP-W			
1471					
1472	PD-FDR2-GEN BUS A	SQUARE D	Interrupting 40.0		
1473		VR			
1474					
1475	PD-FDR2-GEN BUS B	SQUARE D	Interrupting 40.0		
1476		VR			
1477					
1478	PD-FDR2-MSS-BUS A	EATON	Interrupting 40.0		
1479		VCP-W			
1480					
1481	PD-FDR20-MSS-BUS B	EATON	Interrupting 40.0		
1482		VCP-W			
1483					
1484	PD-FDR3-GEN BUS A	SQUARE D	Interrupting 40.0		
1485		VR			
1486					
1487	PD-FDR3-GEN BUS B	SQUARE D	Interrupting 40.0		
1488		VR			
1489					

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1490	PD-FDR3-MSS-BUS A	EATON	Interrupting 40.0		
1491		VCP-W			
1492					
1493	PD-FDR4-GEN BUS A	SQUARE D	Interrupting 40.0		
1494		VR			
1495					
1496	PD-FDR4-GEN BUS B	SQUARE D	Interrupting 40.0		
1497		VR			
1498					
1499	PD-FDR4-MSS-BUS A	EATON	Interrupting 40.0		
1500		VCP-W			
1501					
1502	PD-FDR5-GEN BUS A	SQUARE D	Interrupting 40.0		
1503		VR			
1504					
1505	PD-FDR5-GEN BUS B	SQUARE D	Interrupting 40.0		
1506		VR			
1507					
1508	PD-FDR5-MSS-BUS A	EATON	Interrupting 40.0		
1509		VCP-W			
1510					
1511	PD-FDR6-GEN BUS A	SQUARE D	Interrupting 40.0		
1512		VR			
1513					
1514	PD-FDR6-GEN BUS B	SQUARE D	Interrupting 40.0		
1515		VR			
1516					
1517	PD-FDR6-MSS-BUS A	EATON	Interrupting 40.0		
1518		VCP-W			
1519					
1520	PD-FDR7-GEN BUS A	SQUARE D	Interrupting 40.0		
1521		VR			
1522					
1523	PD-FDR7-GEN BUS B	SQUARE D	Interrupting 40.0		
1524		VR			
1525					
1526	PD-FDR7-MSS-BUS A	EATON	Interrupting 40.0		
1527		VCP-W			
1528					
1529	PD-FDR8-GEN BUS A	SQUARE D	Interrupting 40.0		
1530		VR			
1531					
1532	PD-FDR8-GEN BUS B	SQUARE D	Interrupting 40.0		
1533		VR			
1534					
1535	PD-FDR8-MSS-BUS A	EATON	Interrupting 40.0		
1536		VCP-W			
1537					
1538	PD-FDR9-GEN BUS A	SQUARE D	Interrupting 40.0		
1539		VR			
1540					
1541	PD-FDR9-GEN BUS B	SQUARE D	Interrupting 40.0		
1542		VR			
1543					
1544	PD-FDR9-MSS-BUS A	EATON	Interrupting 40.0		
1545		VCP-W			
1546					
1547	PD-G1 MAIN	SQUARE D	Interrupting 40.0		
1548		VR			
1549					
1550	PD-G10 MAIN	SQUARE D	Interrupting 40.0		
1551		VR			

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1552					
1553	PD-G2 MAIN	SQUARE D	Interrupting 40.0		
1554		VR			
1555					
1556	PD-G3 MAIN	SQUARE D	Interrupting 40.0		
1557		VR			
1558					
1559	PD-G4 MAIN	SQUARE D	Interrupting 40.0		
1560		VR			
1561					
1562	PD-G5 MAIN	SQUARE D	Interrupting 40.0		
1563		VR			
1564					
1565	PD-G6 MAIN	SQUARE D	Interrupting 40.0		
1566		VR			
1567					
1568	PD-G7 MAIN	SQUARE D	Interrupting 40.0		
1569		VR			
1570					
1571	PD-G8 MAIN	SQUARE D	Interrupting 40.0		
1572		VR			
1573					
1574	PD-G9 MAIN	SQUARE D	Interrupting 40.0		
1575		VR			
1576					
1577	PD-GEN BUS-TIE	SQUARE D	Interrupting 40.0		
1578		VR			
1579					
1580	PD-MAIN-BUS A	EATON	Interrupting 40.0		
1581		VCP-W			
1582					
1583	PD-MAIN-BUS B	EATON	Interrupting 40.0		
1584		VCP-W			
1585					
1586	PD-MV-ATS-CUP-CH-A (52E1)	SQUARE D	Interrupting 40.0		
1587		VR			
1588					
1589	PD-MV-ATS-CUP-CH-A (52E2)	SQUARE D	Interrupting 40.0		
1590		VR			
1591					
1592	PD-MV-ATS-CUP-CH-A (52N1)	SQUARE D	Interrupting 40.0		
1593		VR			
1594					
1595	PD-MV-ATS-CUP-CH-A (52N2)	SQUARE D	Interrupting 40.0		
1596		VR			
1597					
1598	PD-MV-ATS-CUP-CH-A (F1)	SQUARE D	Interrupting 40.0		
1599		VR			
1600					
1601	PD-MV-ATS-CUP-CH-A (F2)	SQUARE D	Interrupting 40.0		
1602		VR			
1603					
1604	PD-MV-ATS-CUP-CH-A (F3)	SQUARE D	Interrupting 40.0		
1605		VR			
1606					
1607	PD-MV-ATS-CUP-CH-A (F4)	SQUARE D	Interrupting 40.0		
1608		VR			
1609					
1610	PD-MV-ATS-CUP-CH-B (52E1)	SQUARE D	Interrupting 40.0		
1611		VR			
1612					
1613	PD-MV-ATS-CUP-CH-B (52E2)	SQUARE D	Interrupting 40.0		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1614		VR			
1615					
1616	PD-MV-ATS-CUP-CH-B (52N1)	SQUARE D	Interrupting 40.0		
1617		VR			
1618					
1619	PD-MV-ATS-CUP-CH-B (52N2)	SQUARE D	Interrupting 40.0		
1620		VR			
1621					
1622	PD-MV-ATS-CUP-CH-B (F1)	SQUARE D	Interrupting 40.0		
1623		VR			
1624					
1625	PD-MV-ATS-CUP-CH-B (F2)	SQUARE D	Interrupting 40.0		
1626		VR			
1627					
1628	PD-MV-ATS-CUP-CH-B (F3)	SQUARE D	Interrupting 40.0		
1629		VR			
1630					
1631	PD-MV-ATS-CUP-CH-B (F4)	SQUARE D	Interrupting 40.0		
1632		VR			
1633					
1634	PD-MV-ATS-CUP-MECH-A (52E1)	SQUARE D	Interrupting 40.0		
1635		VR			
1636					
1637	PD-MV-ATS-CUP-MECH-A (52E2)	SQUARE D	Interrupting 40.0		
1638		VR			
1639					
1640	PD-MV-ATS-CUP-MECH-A (52N1)	SQUARE D	Interrupting 40.0		
1641		VR			
1642					
1643	PD-MV-ATS-CUP-MECH-A (52N2)	SQUARE D	Interrupting 40.0		
1644		VR			
1645					
1646	PD-MV-ATS-CUP-MECH-A (F1)	SQUARE D	Interrupting 40.0		
1647		VR			
1648					
1649	PD-MV-ATS-CUP-MECH-A (F2)	SQUARE D	Interrupting 40.0		
1650		VR			
1651					
1652	PD-MV-ATS-CUP-MECH-A (F3)	SQUARE D	Interrupting 40.0		
1653		VR			
1654					
1655	PD-MV-ATS-CUP-MECH-A (F4)	SQUARE D	Interrupting 40.0		
1656		VR			
1657					
1658	PD-MV-ATS-CUP-MECH-B (52E1)	SQUARE D	Interrupting 40.0		
1659		VR			
1660					
1661	PD-MV-ATS-CUP-MECH-B (52E2)	SQUARE D	Interrupting 40.0		
1662		VR			
1663					
1664	PD-MV-ATS-CUP-MECH-B (52N1)	SQUARE D	Interrupting 40.0		
1665		VR			
1666					
1667	PD-MV-ATS-CUP-MECH-B (52N2)	SQUARE D	Interrupting 40.0		
1668		VR			
1669					
1670	PD-MV-ATS-CUP-MECH-B (F1)	SQUARE D	Interrupting 40.0		
1671		VR			
1672					
1673	PD-MV-ATS-CUP-MECH-B (F2)	SQUARE D	Interrupting 40.0		
1674		VR			
1675					

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1676	PD-MV-ATS-CUP-MECH-B (F3)	SQUARE D	Interrupting 40.0		
1677		VR			
1678					
1679	PD-MV-ATS-CUP-MECH-B (F4)	SQUARE D	Interrupting 40.0		
1680		VR			
1681					
1682	PD-MV-ATS-IUH-EQ-A (52E1)	SQUARE D	Interrupting 40.0		
1683		VR			
1684					
1685	PD-MV-ATS-IUH-EQ-A (52E2)	SQUARE D	Interrupting 40.0		
1686		VR			
1687					
1688	PD-MV-ATS-IUH-EQ-A (52N1)	SQUARE D	Interrupting 40.0		
1689		VR			
1690					
1691	PD-MV-ATS-IUH-EQ-A (52N2)	SQUARE D	Interrupting 40.0		
1692		VR			
1693					
1694	PD-MV-ATS-IUH-EQ-A (F1)	SQUARE D	Interrupting 40.0		
1695		VR			
1696					
1697	PD-MV-ATS-IUH-EQ-A (F2)	SQUARE D	Interrupting 40.0		
1698		VR			
1699					
1700	PD-MV-ATS-IUH-EQ-B (52E1)	SQUARE D	Interrupting 40.0		
1701		VR			
1702					
1703	PD-MV-ATS-IUH-EQ-B (52E2)	SQUARE D	Interrupting 40.0		
1704		VR			
1705					
1706	PD-MV-ATS-IUH-EQ-B (52N1)	SQUARE D	Interrupting 40.0		
1707		VR			
1708					
1709	PD-MV-ATS-IUH-EQ-B (52N2)	SQUARE D	Interrupting 40.0		
1710		VR			
1711					
1712	PD-MV-ATS-IUH-EQ-B (F1)	SQUARE D	Interrupting 40.0		
1713		VR			
1714					
1715	PD-MV-ATS-IUH-EQ-B (F2)	SQUARE D	Interrupting 40.0		
1716		VR			
1717					
1718	PD-MV-ATS-IUH-OS-A (52E1)	SQUARE D	Interrupting 40.0		
1719		VR			
1720					
1721	PD-MV-ATS-IUH-OS-A (52E2)	SQUARE D	Interrupting 40.0		
1722		VR			
1723					
1724	PD-MV-ATS-IUH-OS-A (52N1)	SQUARE D	Interrupting 40.0		
1725		VR			
1726					
1727	PD-MV-ATS-IUH-OS-A (52N2)	SQUARE D	Interrupting 40.0		
1728		VR			
1729					
1730	PD-MV-ATS-IUH-OS-A (F1)	SQUARE D	Interrupting 40.0		
1731		VR			
1732					
1733	PD-MV-ATS-IUH-OS-A (F2)	SQUARE D	Interrupting 40.0		
1734		VR			
1735					
1736	PD-MV-ATS-IUH-OS-B (52E1)	SQUARE D	Interrupting 40.0		
1737		VR			

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1738					
1739	PD-MV-ATS-IUH-OS-B (52E2)	SQUARE D	Interrupting 40.0		
1740		VR			
1741					
1742	PD-MV-ATS-IUH-OS-B (52N1)	SQUARE D	Interrupting 40.0		
1743		VR			
1744					
1745	PD-MV-ATS-IUH-OS-B (52N2)	SQUARE D	Interrupting 40.0		
1746		VR			
1747					
1748	PD-MV-ATS-IUH-OS-B (F1)	SQUARE D	Interrupting 40.0		
1749		VR			
1750					
1751	PD-MV-ATS-IUH-OS-B (F2)	SQUARE D	Interrupting 40.0		
1752		VR			
1753					
1754	PD-USS-CH1-BUS A-MAIN	EATON/CUTLER-HAMMER	Interrupting 63.0		
1755		VCP-W			
1756					
1757	PD-USS-CH1-BUS B-MAIN	EATON/CUTLER-HAMMER	Interrupting 63.0		
1758		VCP-W			
1759					
1760	PD-USS-CH2-BUS A-MAIN	EATON/CUTLER-HAMMER	Interrupting 63.0		
1761		VCP-W			
1762					
1763	PD-USS-CH2-BUS B-MAIN	EATON/CUTLER-HAMMER	Interrupting 63.0		
1764		VCP-W			
1765					
1766	**Relays**				
1767	Name/Type	Description	Settings		
1768	RL-BUS-TIE	SEL	Phase		
1769	Electronic	751A	51P1P, (0.5-16 x CTR) 6 (2400A)		
1770			U3, Very Inverse 3.0		
1771			50P1P, (0.5-100 x CTR) 20 (8000A)		
1772			50P1D, (0.001 - 5s) 0.02 sec		
1773			Ground		
1774			51G1P, (0.5-16 x CTR) 2 (800A)		
1775			U4, Extremely Inverse 4.0		
1776			50G1P, (0.5-100 x CTR) 4 (1600A)		
1777			50G1D, (0.001 - 5s) 0.08 sec		
1778			Maint		
1779			51P1P 6 (2400A)		
1780			U3, Very Inverse 3.0		
1781			50P1P 10 (4000A)		
1782			50P1D 0.01 sec		
1783			Optical AF		
1784			50PAF 5 (2000A)		
1785			50PAFD (Standard) 7 ms		
1786					
1787	RL-CH1-BUS A (1):CH#1	SEL	Phase		
1788	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		
1789			U2, Inverse 15.0		
1790			50P1P, (0.5-100 x CTR) 30 (2400A)		
1791			50P1D, (0.001 - 5s) 0.002 sec		
1792			Ground		
1793			51G1P, (0.5-16 x CTR) 2 (160A)		
1794			U4, Extremely Inverse 15.0		
1795			50G1P, (0.5-100 x CTR) 20 (1600A)		
1796			50G1D, (0.001 - 5s) 0.15 sec		
1797					
1798	RL-CH1-BUS A (2):CH#2	SEL	Phase		
1799	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1800			U2, Inverse 15.0		
1801			50P1P, (0.5-100 x CTR) 30 (2400A)		
1802			50P1D, (0.001 - 5s) 0.002 sec		
1803			Ground		
1804			51G1P, (0.5-16 x CTR) 2 (160A)		
1805			U4, Extremely Inverse 15.0		
1806			50G1P, (0.5-100 x CTR) 20 (1600A)		
1807			50G1D, (0.001 - 5s) 0.02 sec		
1808					
1809	RL-CH1-BUS A-MAIN	SEL	Phase		
1810	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1811			U2, Inverse 10.0		
1812			50P1P, (0.5-100 x CTR) 12 (2880A)		
1813			50P1D, (0.001 - 5s) 0.003 sec		
1814			Ground		
1815			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1816			U3, Very Inverse 8.0		
1817			50G1P, (0.5-100 x CTR) 8 (1920A)		
1818			50G1D, (0.001 - 5s) 0.2 sec		
1819					
1820	RL-CH1-BUS A-TIE	SEL	Phase		
1821	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1822			U2, Inverse 10.0		
1823			50P1P, (0.5-100 x CTR) 12 (2880A)		
1824			50P1D, (0.001 - 5s) 0.003 sec		
1825			Ground		
1826			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1827			U3, Very Inverse 8.0		
1828			50G1P, (0.5-100 x CTR) 8 (1920A)		
1829			50G1D, (0.001 - 5s) 0.03 sec		
1830					
1831	RL-CH1-BUS B (1):CH#5	SEL	Phase		
1832	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		
1833			U2, Inverse 15.0		
1834			50P1P, (0.5-100 x CTR) 30 (2400A)		
1835			50P1D, (0.001 - 5s) 0.002 sec		
1836			Ground		
1837			51G1P, (0.5-16 x CTR) 2 (160A)		
1838			U4, Extremely Inverse 15.0		
1839			50G1P, (0.5-100 x CTR) 20 (1600A)		
1840			50G1D, (0.001 - 5s) 0.02 sec		
1841					
1842	RL-CH1-BUS B (2):SPARE	SEL	Phase		
1843	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		
1844			U2, Inverse 15.0		
1845			50P1P, (0.5-100 x CTR) 30 (2400A)		
1846			50P1D, (0.001 - 5s) 0.002 sec		
1847			Ground		
1848			51G1P, (0.5-16 x CTR) 2 (160A)		
1849			U4, Extremely Inverse 15.0		
1850			50G1P, (0.5-100 x CTR) 20 (1600A)		
1851			50G1D, (0.001 - 5s) 0.02 sec		
1852					
1853	RL-CH1-BUS B-MAIN	SEL	Phase		
1854	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1855			U2, Inverse 10.0		
1856			50P1P, (0.5-100 x CTR) 12 (2880A)		
1857			50P1D, (0.001 - 5s) 0.003 sec		
1858			Ground		
1859			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1860			U3, Very Inverse 8.0		
1861			50G1P, (0.5-100 x CTR) 8 (1920A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1862			50G1D, (0.001 - 5s) 0.03 sec		
1863					
1864	RL-CH1-BUS B-TIE	SEL	Phase		
1865	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1866			U2, Inverse 10.0		
1867			50P1P, (0.5-100 x CTR) 12 (2880A)		
1868			50P1D, (0.001 - 5s) 0.003 sec		
1869			Ground		
1870			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1871			U3, Very Inverse 8.0		
1872			50G1P, (0.5-100 x CTR) 8 (1920A)		
1873			50G1D, (0.001 - 5s) 0.03 sec		
1874					
1875	RL-CH2-BUS A (1):CH#2	SEL	Phase		
1876	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		
1877			U2, Inverse 15.0		
1878			50P1P, (0.5-100 x CTR) 30 (2400A)		
1879			50P1D, (0.001 - 5s) 0.002 sec		
1880			Ground		
1881			51G1P, (0.5-16 x CTR) 2 (160A)		
1882			U4, Extremely Inverse 15.0		
1883			50G1P, (0.5-100 x CTR) 20 (1600A)		
1884			50G1D, (0.001 - 5s) 0.02 sec		
1885					
1886	RL-CH2-BUS A (2):CH#4	SEL	Phase		
1887	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		
1888			U2, Inverse 15.0		
1889			50P1P, (0.5-100 x CTR) 30 (2400A)		
1890			50P1D, (0.001 - 5s) 0.002 sec		
1891			Ground		
1892			51G1P, (0.5-16 x CTR) 2 (160A)		
1893			U4, Extremely Inverse 15.0		
1894			50G1P, (0.5-100 x CTR) 20 (1600A)		
1895			50G1D, (0.001 - 5s) 0.02 sec		
1896					
1897	RL-CH2-BUS A-MAIN	SEL	Phase		
1898	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1899			U2, Inverse 10.0		
1900			50P1P, (0.5-100 x CTR) 12 (2880A)		
1901			50P1D, (0.001 - 5s) 0.003 sec		
1902			Ground		
1903			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1904			U3, Very Inverse 8.0		
1905			50G1P, (0.5-100 x CTR) 8 (1920A)		
1906			50G1D, (0.001 - 5s) 0.03 sec		
1907					
1908	RL-CH2-BUS A-TIE	SEL	Phase		
1909	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1910			U2, Inverse 10.0		
1911			50P1P, (0.5-100 x CTR) 12 (2880A)		
1912			50P1D, (0.001 - 5s) 0.003 sec		
1913			Ground		
1914			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1915			U3, Very Inverse 8.0		
1916			50G1P, (0.5-100 x CTR) 8 (1920A)		
1917			50G1D, (0.001 - 5s) 0.03 sec		
1918					
1919	RL-CH2-BUS B (1):CH#6	SEL	Phase		
1920	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		
1921			U2, Inverse 15.0		
1922			50P1P, (0.5-100 x CTR) 30 (2400A)		
1923			50P1D, (0.001 - 5s) 0.002 sec		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1924			Ground		
1925			51G1P, (0.5-16 x CTR) 2 (160A)		
1926			U4, Extremely Inverse 15.0		
1927			50G1P, (0.5-100 x CTR) 20 (1600A)		
1928			50G1D, (0.001 - 5s) 0.02 sec		
1929					
1930	RL-CH2-BUS B (2):SPARE	SEL	Phase		
1931	Electronic	751	51P1P, (0.5-16 x CTR) 4 (320A)		
1932			U2, Inverse 15.0		
1933			50P1P, (0.5-100 x CTR) 30 (2400A)		
1934			50P1D, (0.001 - 5s) 0.002 sec		
1935			Ground		
1936			51G1P, (0.5-16 x CTR) 2 (160A)		
1937			U4, Extremely Inverse 15.0		
1938			50G1P, (0.5-100 x CTR) 20 (1600A)		
1939			50G1D, (0.001 - 5s) 0.02 sec		
1940					
1941	RL-CH2-BUS B-MAIN	SEL	Phase		
1942	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1943			U2, Inverse 10.0		
1944			50P1P, (0.5-100 x CTR) 12 (2880A)		
1945			50P1D, (0.001 - 5s) 0.003 sec		
1946			Ground		
1947			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1948			U3, Very Inverse 8.0		
1949			50G1P, (0.5-100 x CTR) 8 (1920A)		
1950			50G1D, (0.001 - 5s) 0.03 sec		
1951					
1952	RL-CH2-BUS B-TIE	SEL	Phase		
1953	Electronic	751	51P1P, (0.5-16 x CTR) 3 (720A)		
1954			U2, Inverse 10.0		
1955			50P1P, (0.5-100 x CTR) 12 (2880A)		
1956			50P1D, (0.001 - 5s) 0.003 sec		
1957			Ground		
1958			51G1P, (0.5-16 x CTR) 1.5 (360A)		
1959			U3, Very Inverse 8.0		
1960			50G1P, (0.5-100 x CTR) 8 (1920A)		
1961			50G1D, (0.001 - 5s) 0.03 sec		
1962					
1963	RL-FDR1-GEN BUS A:IUH-OS-A	SEL	Phase		
1964	Electronic	751	51P1P 3.6 (864A)		
1965			U4, Extremely Inverse 3.1		
1966			50P1P 31 (7440A)		
1967			50P1D 0.02 sec		
1968			Ground		
1969			51G1P 1.6 (384A)		
1970			U4, Extremely Inverse 4.0		
1971			50G1P 4.2 (1008A)		
1972			50G1D 0.32 sec		
1973			Optical AF		
1974			50PAF 3 (720A)		
1975			50PAFD (Standard) 13 ms		
1976					
1977	RL-FDR1-GEN BUS B:CUP-CH B	SEL	Phase		
1978	Electronic	751	51P1P 3.6 (864A)		
1979			U4, Extremely Inverse 3.1		
1980			50P1P 31 (7440A)		
1981			50P1D 0.02 sec		
1982			Ground		
1983			51G1P 1.6 (384A)		
1984			U4, Extremely Inverse 4.0		
1985			50G1P 4.2 (1008A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
1986			50G1D 0.32 sec		
1987			Optical AF		
1988			50PAF 3 (720A)		
1989			50PAFD (Standard) 13 ms		
1990					
1991	RL-FDR1-MSS_A:FUTURE PFC	SEL	Phase		
1992	Electronic	751	51P1P 3.6 (864A)		
1993			U4, Extremely Inverse 3.1		
1994			50P1P 31 (7440A)		
1995			50P1D 0.02 sec		
1996			Ground		
1997			51G1P 1.6 (384A)		
1998			U4, Extremely Inverse 4.0		
1999			50G1P 4.2 (1008A)		
2000			50G1D 0.32 sec		
2001			Maint		
2002			51P1P 3.5 (840A)		
2003			U4, Extremely Inverse 2.5		
2004			50P1P 10 (2400A)		
2005			50P1D 0.01 sec		
2006			Optical AF		
2007			50PAF 3 (720A)		
2008			50PAFD (Standard) 13 ms		
2009					
2010	RL-FDR10-GEN BUS A:SPARE	SEL	Phase		
2011	Electronic	751	51P1P 3.6 (864A)		
2012			U4, Extremely Inverse 3.1		
2013			50P1P 31 (7440A)		
2014			50P1D 0.02 sec		
2015			Ground		
2016			51G1P 1.6 (384A)		
2017			U4, Extremely Inverse 4.0		
2018			50G1P 4.2 (1008A)		
2019			50G1D 0.32 sec		
2020			Optical AF		
2021			50PAF 3 (720A)		
2022			50PAFD (Standard) 13 ms		
2023					
2024	RL-FDR10-GEN BUS B:SPARE	SEL	Phase		
2025	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2026			U4, Extremely Inverse 3.0		
2027			50P1P, (0.5-100 x CTR) 20 (1600A)		
2028			50P1D, (0.001 - 5s) 0.07 sec		
2029			Ground		
2030			51G1P, (0.5-16 x CTR) 3 (240A)		
2031			U4, Extremely Inverse 2.0		
2032			50G1P, (0.5-100 x CTR) 20 (1600A)		
2033			50G1D, (0.001 - 5s) 0.2 sec		
2034			Optical AF		
2035			50PAF 3 (240A)		
2036			50PAFD (Standard) 7 ms		
2037					
2038	RL-FDR10-MSS_A:SSB-A	SEL	Phase		
2039	Electronic	751	51P1P 3.6 (864A)		
2040			U4, Extremely Inverse 3.1		
2041			50P1P 31 (7440A)		
2042			50P1D 0.02 sec		
2043			Ground		
2044			51G1P 1.6 (384A)		
2045			U4, Extremely Inverse 4.0		
2046			50G1P 4.2 (1008A)		
2047			50G1D 0.32 sec		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2048			Maint		
2049			51P1P 3.5 (840A)		
2050			U4, Extremely Inverse 2.5		
2051			50P1P 10 (2400A)		
2052			50P1D 0.01 sec		
2053			Optical AF		
2054			50PAF 3 (720A)		
2055			50PAFD (Standard) 13 ms		
2056					
2057	RL-FDR11-MSS_B:SSB-B	SEL	Phase		
2058	Electronic	751	51P1P 3.6 (864A)		
2059			U4, Extremely Inverse 3.1		
2060			50P1P 31 (7440A)		
2061			50P1D 0.02 sec		
2062			Ground		
2063			51G1P 1.6 (384A)		
2064			U4, Extremely Inverse 4.0		
2065			50G1P 4.2 (1008A)		
2066			50G1D 0.32 sec		
2067			Maint		
2068			51P1P 3.5 (840A)		
2069			U4, Extremely Inverse 2.5		
2070			50P1P 10 (2400A)		
2071			50P1D 0.01 sec		
2072			Optical AF		
2073			50PAF 3 (720A)		
2074			50PAFD (Standard) 13 ms		
2075					
2076	RL-FDR12-MSS_B:PG-B	SEL	Phase		
2077	Electronic	751	51P1P 3.6 (864A)		
2078			U4, Extremely Inverse 3.1		
2079			50P1P 31 (7440A)		
2080			50P1D 0.02 sec		
2081			Ground		
2082			51G1P 1.6 (384A)		
2083			U4, Extremely Inverse 4.0		
2084			50G1P 4.2 (1008A)		
2085			50G1D 0.32 sec		
2086			Maint		
2087			51P1P 3.5 (840A)		
2088			U4, Extremely Inverse 2.5		
2089			50P1P 10 (2400A)		
2090			50P1D 0.01 sec		
2091			Optical AF		
2092			50PAF 3 (720A)		
2093			50PAFD (Standard) 13 ms		
2094					
2095	RL-FDR13-MSS_B:SPARE (EV-1)	SEL	Phase		
2096	Electronic	751	51P1P 3.6 (864A)		
2097			U4, Extremely Inverse 3.1		
2098			50P1P 31 (7440A)		
2099			50P1D 0.02 sec		
2100			Ground		
2101			51G1P 1.6 (384A)		
2102			U4, Extremely Inverse 4.0		
2103			50G1P 4.2 (1008A)		
2104			50G1D 0.32 sec		
2105			Maint		
2106			51P1P 3.5 (840A)		
2107			U4, Extremely Inverse 2.5		
2108			50P1P 10 (2400A)		
2109			50P1D 0.01 sec		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2110			Optical AF		
2111			50PAF 3 (720A)		
2112			50PAFD (Standard) 13 ms		
2113					
2114	RL-FDR14-MSS_B:CUP-CH B	SEL	Phase		
2115	Electronic	751	51P1P 3.6 (864A)		
2116			U4, Extremely Inverse 3.1		
2117			50P1P 31 (7440A)		
2118			50P1D 0.02 sec		
2119			Ground		
2120			51G1P 1.6 (384A)		
2121			U4, Extremely Inverse 4.0		
2122			50G1P 4.2 (1008A)		
2123			50G1D 0.32 sec		
2124			Maint		
2125			51P1P 3.5 (840A)		
2126			U4, Extremely Inverse 2.5		
2127			50P1P 10 (2400A)		
2128			50P1D 0.01 sec		
2129			Optical AF		
2130			50PAF 3 (720A)		
2131			50PAFD (Standard) 13 ms		
2132					
2133	RL-FDR15-MSS_B:CUP-MECH B	SEL	Phase		
2134	Electronic	751	51P1P 3.6 (864A)		
2135			U4, Extremely Inverse 3.1		
2136			50P1P 31 (7440A)		
2137			50P1D 0.02 sec		
2138			Ground		
2139			51G1P 1.6 (384A)		
2140			U4, Extremely Inverse 4.0		
2141			50G1P 4.2 (1008A)		
2142			50G1D 0.32 sec		
2143			Maint		
2144			51P1P 3.5 (840A)		
2145			U4, Extremely Inverse 2.5		
2146			50P1P 10 (2400A)		
2147			50P1D 0.01 sec		
2148			Optical AF		
2149			50PAF 3 (720A)		
2150			50PAFD (Standard) 13 ms		
2151					
2152	RL-FDR16-MSS_B:IUH-EQ-B	SEL	Phase		
2153	Electronic	751	51P1P 3.6 (864A)		
2154			U4, Extremely Inverse 3.1		
2155			50P1P 31 (7440A)		
2156			50P1D 0.02 sec		
2157			Ground		
2158			51G1P 1.6 (384A)		
2159			U4, Extremely Inverse 4.0		
2160			50G1P 4.2 (1008A)		
2161			50G1D 0.32 sec		
2162			Maint		
2163			51P1P 3.5 (840A)		
2164			U4, Extremely Inverse 2.5		
2165			50P1P 10 (2400A)		
2166			50P1D 0.01 sec		
2167			Optical AF		
2168			50PAF 3 (720A)		
2169			50PAFD (Standard) 13 ms		
2170					
2171	RL-FDR17-MSS_B:IUH-OS-B	SEL	Phase		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2172	Electronic	751	51P1P 3.6 (864A)		
2173			U4, Extremely Inverse 3.1		
2174			50P1P 31 (7440A)		
2175			50P1D 0.02 sec		
2176			Ground		
2177			51G1P 1.6 (384A)		
2178			U4, Extremely Inverse 4.0		
2179			50G1P 4.2 (1008A)		
2180			50G1D 0.32 sec		
2181			Maint		
2182			51P1P 3.5 (840A)		
2183			U4, Extremely Inverse 2.5		
2184			50P1P 10 (2400A)		
2185			50P1D 0.01 sec		
2186			Optical AF		
2187			50PAF 3 (720A)		
2188			50PAFD (Standard) 13 ms		
2189					
2190	RL-FDR18-MSS_B:FUTURE PFC	SEL	Phase		
2191	Electronic	751	51P1P 3.6 (864A)		
2192			U4, Extremely Inverse 3.1		
2193			50P1P 31 (7440A)		
2194			50P1D 0.02 sec		
2195			Ground		
2196			51G1P 1.6 (384A)		
2197			U4, Extremely Inverse 4.0		
2198			50G1P 4.2 (1008A)		
2199			50G1D 0.32 sec		
2200			Maint		
2201			51P1P 3.5 (840A)		
2202			U4, Extremely Inverse 2.5		
2203			50P1P 10 (2400A)		
2204			50P1D 0.01 sec		
2205			Optical AF		
2206			50PAF 3 (720A)		
2207			50PAFD (Standard) 13 ms		
2208					
2209	RL-FDR19-MSS_B:SPARE	SEL	Phase		
2210	Electronic	751	51P1P 3.6 (864A)		
2211			U4, Extremely Inverse 3.1		
2212			50P1P 31 (7440A)		
2213			50P1D 0.02 sec		
2214			Ground		
2215			51G1P 1.6 (384A)		
2216			U4, Extremely Inverse 4.0		
2217			50G1P 4.2 (1008A)		
2218			50G1D 0.32 sec		
2219			Maint		
2220			51P1P 3.5 (840A)		
2221			U4, Extremely Inverse 2.5		
2222			50P1P 10 (2400A)		
2223			50P1D 0.01 sec		
2224			Optical AF		
2225			50PAF 3 (720A)		
2226			50PAFD (Standard) 13 ms		
2227					
2228	RL-FDR2-GEN BUS A:IUH-EQ-A	SEL	Phase		
2229	Electronic	751	51P1P 3.5 (840A)		
2230			U4, Extremely Inverse 3.0		
2231			50P1P 10 (2400A)		
2232			50P1D 0.01 sec		
2233			Ground		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2234			51G1P 2 (480A)		
2235			U3, Very Inverse 3.0		
2236			50G1P 10 (2400A)		
2237			50G1D 0.3 sec		
2238			Optical AF		
2239			50PAF 5 (1200A)		
2240			50PAFD (Standard) 7 ms		
2241					
2242	RL-FDR2-GEN BUS B:CUP-MECH B	SEL	Phase		
2243	Electronic	751	51P1P 3.6 (864A)		
2244			U4, Extremely Inverse 3.1		
2245			50P1P 31 (7440A)		
2246			50P1D 0.02 sec		
2247			Ground		
2248			51G1P 1.6 (384A)		
2249			U4, Extremely Inverse 4.0		
2250			50G1P 4.2 (1008A)		
2251			50G1D 0.32 sec		
2252			Optical AF		
2253			50PAF 3 (720A)		
2254			50PAFD (Standard) 13 ms		
2255					
2256	RL-FDR2-MSS_A:SPARE	SEL	Phase		
2257	Electronic	751	51P1P 3.6 (864A)		
2258			U4, Extremely Inverse 3.1		
2259			50P1P 31 (7440A)		
2260			50P1D 0.02 sec		
2261			Ground		
2262			51G1P 1.6 (384A)		
2263			U4, Extremely Inverse 4.0		
2264			50G1P 4.2 (1008A)		
2265			50G1D 0.32 sec		
2266			Maint		
2267			51P1P 3.5 (840A)		
2268			U4, Extremely Inverse 2.5		
2269			50P1P 10 (2400A)		
2270			50P1D 0.01 sec		
2271			Optical AF		
2272			50PAF 3 (720A)		
2273			50PAFD (Standard) 13 ms		
2274					
2275	RL-FDR20-MSS_B:SPARE	SEL	Phase		
2276	Electronic	751	51P1P 3.6 (864A)		
2277			U4, Extremely Inverse 3.1		
2278			50P1P 31 (7440A)		
2279			50P1D 0.02 sec		
2280			Ground		
2281			51G1P 1.6 (384A)		
2282			U4, Extremely Inverse 4.0		
2283			50G1P 4.2 (1008A)		
2284			50G1D 0.32 sec		
2285			Maint		
2286			51P1P 3.5 (840A)		
2287			U4, Extremely Inverse 2.5		
2288			50P1P 10 (2400A)		
2289			50P1D 0.01 sec		
2290			Optical AF		
2291			50PAF 3 (720A)		
2292			50PAFD (Standard) 13 ms		
2293					
2294	RL-FDR3-GEN BUS A:CUP-MECH A	SEL	Phase		
2295	Electronic	751	51P1P 3.6 (864A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2296			U4, Extremely Inverse 3.1		
2297			50P1P 31 (7440A)		
2298			50P1D 0.02 sec		
2299			Ground		
2300			51G1P 1.6 (384A)		
2301			U4, Extremely Inverse 4.0		
2302			50G1P 4.2 (1008A)		
2303			50G1D 0.32 sec		
2304			Optical AF		
2305			50PAF 3 (720A)		
2306			50PAFD (Standard) 13 ms		
2307					
2308	RL-FDR3-GEN BUS B:IUH-EQ-B	SEL	Phase		
2309	Electronic	751	51P1P 3.6 (864A)		
2310			U4, Extremely Inverse 3.1		
2311			50P1P 31 (7440A)		
2312			50P1D 0.02 sec		
2313			Ground		
2314			51G1P 1.6 (384A)		
2315			U4, Extremely Inverse 4.0		
2316			50G1P 4.2 (1008A)		
2317			50G1D 0.32 sec		
2318			Optical AF		
2319			50PAF 3 (720A)		
2320			50PAFD (Standard) 13 ms		
2321					
2322	RL-FDR3-MSS_A:IUH OS-A	SEL	Phase		
2323	Electronic	751	51P1P 3.6 (864A)		
2324			U4, Extremely Inverse 3.1		
2325			50P1P 31 (7440A)		
2326			50P1D 0.02 sec		
2327			Ground		
2328			51G1P 1.6 (384A)		
2329			U4, Extremely Inverse 4.0		
2330			50G1P 4.2 (1008A)		
2331			50G1D 0.32 sec		
2332			Maint		
2333			51P1P 3.5 (840A)		
2334			U4, Extremely Inverse 2.5		
2335			50P1P 10 (2400A)		
2336			50P1D 0.01 sec		
2337			Optical AF		
2338			50PAF 3 (720A)		
2339			50PAFD (Standard) 13 ms		
2340					
2341	RL-FDR4-GEN BUS A:CUP-CH A	SEL	Phase		
2342	Electronic	751	51P1P 3.6 (864A)		
2343			U4, Extremely Inverse 3.1		
2344			50P1P 31 (7440A)		
2345			50P1D 0.02 sec		
2346			Ground		
2347			51G1P 1.6 (384A)		
2348			U4, Extremely Inverse 4.0		
2349			50G1P 4.2 (1008A)		
2350			50G1D 0.32 sec		
2351			Optical AF		
2352			50PAF 3 (720A)		
2353			50PAFD (Standard) 13 ms		
2354					
2355	RL-FDR4-GEN BUS B:IUH-OS-B	SEL	Phase		
2356	Electronic	751	51P1P 3.6 (864A)		
2357			U4, Extremely Inverse 3.1		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2358			50P1P 31 (7440A)		
2359			50P1D 0.02 sec		
2360			Ground		
2361			51G1P 1.6 (384A)		
2362			U4, Extremely Inverse 4.0		
2363			50G1P 4.2 (1008A)		
2364			50G1D 0.32 sec		
2365			Optical AF		
2366			50PAF 3 (720A)		
2367			50PAFD (Standard) 13 ms		
2368					
2369	RL-FDR4-MSS_A:IUH EQ-A	SEL	Phase		
2370	Electronic	751	51P1P 3.6 (864A)		
2371			U4, Extremely Inverse 3.1		
2372			50P1P 31 (7440A)		
2373			50P1D 0.02 sec		
2374			Ground		
2375			51G1P 1.6 (384A)		
2376			U4, Extremely Inverse 4.0		
2377			50G1P 4.2 (1008A)		
2378			50G1D 0.32 sec		
2379			Maint		
2380			51P1P 3.5 (840A)		
2381			U4, Extremely Inverse 2.5		
2382			50P1P 10 (2400A)		
2383			50P1D 0.01 sec		
2384			Optical AF		
2385			50PAF 3 (720A)		
2386			50PAFD (Standard) 13 ms		
2387					
2388	RL-FDR5-GEN BUS A:SBB ESS	SEL	Phase		
2389	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2390			U4, Extremely Inverse 3.0		
2391			50P1P, (0.5-100 x CTR) 20 (1600A)		
2392			50P1D, (0.001 - 5s) 0.07 sec		
2393			Ground		
2394			51G1P, (0.5-16 x CTR) 3 (240A)		
2395			U4, Extremely Inverse 2.0		
2396			50G1P, (0.5-100 x CTR) 20 (1600A)		
2397			50G1D, (0.001 - 5s) 0.2 sec		
2398			Optical AF		
2399			50PAF 3 (240A)		
2400			50PAFD (Standard) 7 ms		
2401					
2402	RL-FDR5-GEN BUS B:IUH-ESS-B	SEL	Phase		
2403	Electronic	751	51P1P 3.6 (864A)		
2404			U4, Extremely Inverse 3.1		
2405			50P1P 31 (7440A)		
2406			50P1D 0.02 sec		
2407			Ground		
2408			51G1P 1.6 (384A)		
2409			U4, Extremely Inverse 4.0		
2410			50G1P 4.2 (1008A)		
2411			50G1D 0.32 sec		
2412			Optical AF		
2413			50PAF 3 (720A)		
2414			50PAFD (Standard) 13 ms		
2415					
2416	RL-FDR5-MSS_A:CUP-MECH A	SEL	Phase		
2417	Electronic	751	51P1P 3.6 (864A)		
2418			U4, Extremely Inverse 3.1		
2419			50P1P 31 (7440A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2420			50P1D 0.02 sec		
2421			Ground		
2422			51G1P 1.6 (384A)		
2423			U4, Extremely Inverse 4.0		
2424			50G1P 4.2 (1008A)		
2425			50G1D 0.32 sec		
2426			Maint		
2427			51P1P 3.5 (840A)		
2428			U4, Extremely Inverse 2.5		
2429			50P1P 10 (2400A)		
2430			50P1D 0.01 sec		
2431			Optical AF		
2432			50PAF 3 (720A)		
2433			50PAFD (Standard) 13 ms		
2434					
2435	RL-FDR6-GEN BUS A:PG ESS	SEL	Phase		
2436	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2437			U4, Extremely Inverse 3.0		
2438			50P1P, (0.5-100 x CTR) 20 (1600A)		
2439			50P1D, (0.001 - 5s) 0.07 sec		
2440			Ground		
2441			51G1P, (0.5-16 x CTR) 3 (240A)		
2442			U4, Extremely Inverse 2.0		
2443			50G1P, (0.5-100 x CTR) 20 (1600A)		
2444			50G1D, (0.001 - 5s) 0.2 sec		
2445			Optical AF		
2446			50PAF 3 (240A)		
2447			50PAFD (Standard) 7 ms		
2448					
2449	RL-FDR6-GEN BUS B:ESS CUP	SEL	Phase		
2450	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2451			U4, Extremely Inverse 3.0		
2452			50P1P, (0.5-100 x CTR) 20 (1600A)		
2453			50P1D, (0.001 - 5s) 0.07 sec		
2454			Ground		
2455			51G1P, (0.5-16 x CTR) 3 (240A)		
2456			U4, Extremely Inverse 2.0		
2457			50G1P, (0.5-100 x CTR) 20 (1600A)		
2458			50G1D, (0.001 - 5s) 0.2 sec		
2459			Optical AF		
2460			50PAF 3 (240A)		
2461			50PAFD (Standard) 7 ms		
2462					
2463	RL-FDR6-MSS_A:CUP-CH A	SEL	Phase		
2464	Electronic	751	51P1P 3.6 (864A)		
2465			U4, Extremely Inverse 3.1		
2466			50P1P 31 (7440A)		
2467			50P1D 0.02 sec		
2468			Ground		
2469			51G1P 1.6 (384A)		
2470			U4, Extremely Inverse 4.0		
2471			50G1P 4.2 (1008A)		
2472			50G1D 0.32 sec		
2473			Maint		
2474			51P1P 3.5 (840A)		
2475			U4, Extremely Inverse 2.5		
2476			50P1P 10 (2400A)		
2477			50P1D 0.01 sec		
2478			Optical AF		
2479			50PAF 3 (720A)		
2480			50PAFD (Standard) 13 ms		
2481					

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2482	RL-FDR7-GEN BUS A:SPARE	SEL	Phase		
2483	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2484			U4, Extremely Inverse 3.0		
2485			50P1P, (0.5-100 x CTR) 20 (1600A)		
2486			50P1D, (0.001 - 5s) 0.07 sec		
2487			Ground		
2488			51G1P, (0.5-16 x CTR) 3 (240A)		
2489			U4, Extremely Inverse 2.0		
2490			50G1P, (0.5-100 x CTR) 20 (1600A)		
2491			50G1D, (0.001 - 5s) 0.2 sec		
2492			Optical AF		
2493			50PAF 3 (240A)		
2494			50PAFD (Standard) 7 ms		
2495					
2496	RL-FDR7-GEN BUS B:SPARE	SEL	Phase		
2497	Electronic	751	51P1P 3.6 (864A)		
2498			U4, Extremely Inverse 3.1		
2499			50P1P 31 (7440A)		
2500			50P1D 0.02 sec		
2501			Ground		
2502			51G1P 1.6 (384A)		
2503			U4, Extremely Inverse 4.0		
2504			50G1P 4.2 (1008A)		
2505			50G1D 0.32 sec		
2506			Optical AF		
2507			50PAF 3 (720A)		
2508			50PAFD (Standard) 13 ms		
2509					
2510	RL-FDR7-MSS_A:EV1	SEL	Phase		
2511	Electronic	751	51P1P 3.6 (864A)		
2512			U4, Extremely Inverse 3.1		
2513			50P1P 31 (7440A)		
2514			50P1D 0.02 sec		
2515			Ground		
2516			51G1P 1.6 (384A)		
2517			U4, Extremely Inverse 4.0		
2518			50G1P 4.2 (1008A)		
2519			50G1D 0.32 sec		
2520			Maint		
2521			51P1P 3.5 (840A)		
2522			U4, Extremely Inverse 2.5		
2523			50P1P 10 (2400A)		
2524			50P1D 0.01 sec		
2525			Optical AF		
2526			50PAF 3 (720A)		
2527			50PAFD (Standard) 13 ms		
2528					
2529	RL-FDR8-GEN BUS A:IUH ESS-A	SEL	Phase		
2530	Electronic	751	51P1P 3.6 (864A)		
2531			U4, Extremely Inverse 3.1		
2532			50P1P 31 (7440A)		
2533			50P1D 0.02 sec		
2534			Ground		
2535			51G1P 1.6 (384A)		
2536			U4, Extremely Inverse 4.0		
2537			50G1P 4.2 (1008A)		
2538			50G1D 0.32 sec		
2539			Optical AF		
2540			50PAF 3 (720A)		
2541			50PAFD (Standard) 13 ms		
2542					
2543	RL-FDR8-GEN BUS B:SPARE	SEL	Phase		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2544	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2545			U4, Extremely Inverse 3.0		
2546			50P1P, (0.5-100 x CTR) 20 (1600A)		
2547			50P1D, (0.001 - 5s) 0.07 sec		
2548			Ground		
2549			51G1P, (0.5-16 x CTR) 3 (240A)		
2550			U4, Extremely Inverse 2.0		
2551			50G1P, (0.5-100 x CTR) 20 (1600A)		
2552			50G1D, (0.001 - 5s) 0.2 sec		
2553			Optical AF		
2554			50PAF 3 (240A)		
2555			50PAFD (Standard) 7 ms		
2556					
2557	RL-FDR8-MSS_A:SPARE	SEL	Phase		
2558	Electronic	751	51P1P 3.6 (864A)		
2559			U4, Extremely Inverse 3.1		
2560			50P1P 31 (7440A)		
2561			50P1D 0.02 sec		
2562			Ground		
2563			51G1P 1.6 (384A)		
2564			U4, Extremely Inverse 4.0		
2565			50G1P 4.2 (1008A)		
2566			50G1D 0.32 sec		
2567			Maint		
2568			51P1P 3.5 (840A)		
2569			U4, Extremely Inverse 2.5		
2570			50P1P 10 (2400A)		
2571			50P1D 0.01 sec		
2572			Optical AF		
2573			50PAF 3 (720A)		
2574			50PAFD (Standard) 13 ms		
2575					
2576	RL-FDR9-GEN BUS A:SPARE	SEL	Phase		
2577	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2578			U4, Extremely Inverse 3.0		
2579			50P1P, (0.5-100 x CTR) 20 (1600A)		
2580			50P1D, (0.001 - 5s) 0.07 sec		
2581			Ground		
2582			51G1P, (0.5-16 x CTR) 3 (240A)		
2583			U4, Extremely Inverse 2.0		
2584			50G1P, (0.5-100 x CTR) 20 (1600A)		
2585			50G1D, (0.001 - 5s) 0.2 sec		
2586			Optical AF		
2587			50PAF 3 (240A)		
2588			50PAFD (Standard) 7 ms		
2589					
2590	RL-FDR9-GEN BUS B:3MW LD BNK	SEL	Phase		
2591	Electronic	751	51P1P, (0.5-16 x CTR) 3 (240A)		
2592			U4, Extremely Inverse 3.0		
2593			50P1P, (0.5-100 x CTR) 20 (1600A)		
2594			50P1D, (0.001 - 5s) 0.07 sec		
2595			Ground		
2596			51G1P, (0.5-16 x CTR) 3 (240A)		
2597			U4, Extremely Inverse 2.0		
2598			50G1P, (0.5-100 x CTR) 20 (1600A)		
2599			50G1D, (0.001 - 5s) 0.2 sec		
2600			Optical AF		
2601			50PAF 3 (240A)		
2602			50PAFD (Standard) 7 ms		
2603					
2604	RL-FDR9-MSS_A:PG-A	SEL	Phase		
2605	Electronic	751	51P1P 3.6 (864A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2606			U4, Extremely Inverse 3.1		
2607			50P1P 31 (7440A)		
2608			50P1D 0.02 sec		
2609			Ground		
2610			51G1P 1.6 (384A)		
2611			U4, Extremely Inverse 4.0		
2612			50G1P 4.2 (1008A)		
2613			50G1D 0.32 sec		
2614			Maint		
2615			51P1P 3.5 (840A)		
2616			U4, Extremely Inverse 2.5		
2617			50P1P 10 (2400A)		
2618			50P1D 0.01 sec		
2619			Optical AF		
2620			50PAF 3 (720A)		
2621			50PAFD (Standard) 13 ms		
2622					
2623	RL-G1 MAIN	SEL	Phase		
2624	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2625			U4, Extremely Inverse 5		
2626			50P, (0.5-96 x CTR) 60 (4800A)		
2627			50P1D, (0.001 - 5s) 0.01 sec		
2628			Ground		
2629			51G, (0.5-16 x CTR) 6 (480A)		
2630			U1, Moderately Inverse 3		
2631			AF - SEL751A		
2632			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2633			50PAFD (2 - 5 ms) 2 ms		
2634					
2635	RL-G10 MAIN	SEL	Phase		
2636	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2637			U4, Extremely Inverse 5		
2638			50P, (0.5-96 x CTR) 60 (4800A)		
2639			50P1D, (0.001 - 5s) 0.01 sec		
2640			Ground		
2641			51G, (0.5-16 x CTR) 6 (480A)		
2642			U1, Moderately Inverse 3		
2643			AF - SEL751A		
2644			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2645			50PAFD (2 - 5 ms) 2 ms		
2646					
2647	RL-G2 MAIN	SEL	Phase		
2648	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2649			U4, Extremely Inverse 5		
2650			50P, (0.5-96 x CTR) 60 (4800A)		
2651			50P1D, (0.001 - 5s) 0.01 sec		
2652			Ground		
2653			51G, (0.5-16 x CTR) 6 (480A)		
2654			U1, Moderately Inverse 3		
2655			AF - SEL751A		
2656			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2657			50PAFD (2 - 5 ms) 2 ms		
2658					
2659	RL-G3 MAIN	SEL	Phase		
2660	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2661			U4, Extremely Inverse 5		
2662			50P, (0.5-96 x CTR) 60 (4800A)		
2663			50P1D, (0.001 - 5s) 0.01 sec		
2664			Ground		
2665			51G, (0.5-16 x CTR) 6 (480A)		
2666			U1, Moderately Inverse 3		
2667			AF - SEL751A		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2668			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2669			50PAFD (2 - 5 ms) 2 ms		
2670					
2671	RL-G4 MAIN	SEL	Phase		
2672	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2673			U4, Extremely Inverse 5		
2674			50P, (0.5-96 x CTR) 60 (4800A)		
2675			50P1D, (0.001 - 5s) 0.01 sec		
2676			Ground		
2677			51G, (0.5-16 x CTR) 6 (480A)		
2678			U1, Moderately Inverse 3		
2679			AF - SEL751A		
2680			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2681			50PAFD (2 - 5 ms) 2 ms		
2682					
2683	RL-G5 MAIN	SEL	Phase		
2684	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2685			U4, Extremely Inverse 5		
2686			50P, (0.5-96 x CTR) 60 (4800A)		
2687			50P1D, (0.001 - 5s) 0.01 sec		
2688			Ground		
2689			51G, (0.5-16 x CTR) 6 (480A)		
2690			U1, Moderately Inverse 3		
2691			AF - SEL751A		
2692			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2693			50PAFD (2 - 5 ms) 2 ms		
2694					
2695	RL-G6 MAIN	SEL	Phase		
2696	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2697			U4, Extremely Inverse 5		
2698			50P, (0.5-96 x CTR) 60 (4800A)		
2699			50P1D, (0.001 - 5s) 0.01 sec		
2700			Ground		
2701			51G, (0.5-16 x CTR) 6 (480A)		
2702			U1, Moderately Inverse 3		
2703			AF - SEL751A		
2704			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2705			50PAFD (2 - 5 ms) 2 ms		
2706					
2707	RL-G7 MAIN	SEL	Phase		
2708	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2709			U4, Extremely Inverse 5		
2710			50P, (0.5-96 x CTR) 60 (4800A)		
2711			50P1D, (0.001 - 5s) 0.01 sec		
2712			Ground		
2713			51G, (0.5-16 x CTR) 6 (480A)		
2714			U1, Moderately Inverse 3		
2715			AF - SEL751A		
2716			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2717			50PAFD (2 - 5 ms) 2 ms		
2718					
2719	RL-G8 MAIN	SEL	Phase		
2720	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2721			U4, Extremely Inverse 5		
2722			50P, (0.5-96 x CTR) 60 (4800A)		
2723			50P1D, (0.001 - 5s) 0.01 sec		
2724			Ground		
2725			51G, (0.5-16 x CTR) 6 (480A)		
2726			U1, Moderately Inverse 3		
2727			AF - SEL751A		
2728			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2729			50PAFD (2 - 5 ms) 2 ms		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2730					
2731	RL-G9 MAIN	SEL	Phase		
2732	Static Relay	700G	51P, (0.5-16 x CTR) 5 (400A)		
2733			U4, Extremely Inverse 5		
2734			50P, (0.5-96 x CTR) 60 (4800A)		
2735			50P1D, (0.001 - 5s) 0.01 sec		
2736			Ground		
2737			51G, (0.5-16 x CTR) 6 (480A)		
2738			U1, Moderately Inverse 3		
2739			AF - SEL751A		
2740			50PAF (0.5 - 100 x CTR) 70 (5600A)		
2741			50PAFD (2 - 5 ms) 2 ms		
2742					
2743	RL-GEN BUS-TIE	SEL	Phase		
2744	Electronic	751A	51P1P, (0.5-16 x CTR) 6 (2400A)		
2745			U3, Very Inverse 3.0		
2746			50P1P, (0.5-100 x CTR) 20 (8000A)		
2747			50P1D, (0.001 - 5s) 0.02 sec		
2748			Ground		
2749			51G1P, (0.5-16 x CTR) 2 (800A)		
2750			U4, Extremely Inverse 4.0		
2751			50G1P, (0.5-100 x CTR) 4 (1600A)		
2752			50G1D, (0.001 - 5s) 0.08 sec		
2753			Optical AF		
2754			50PAF 5 (2000A)		
2755			50PAFD (Standard) 7 ms		
2756					
2757	RL-MAIN-BUS A	SEL	Phase		
2758	Electronic	751A	51P1P, (0.5-16 x CTR) 6 (2400A)		
2759			U3, Very Inverse 3.0		
2760			50P1P, (0.5-100 x CTR) 20 (8000A)		
2761			50P1D, (0.001 - 5s) 0.02 sec		
2762			Ground		
2763			51G1P, (0.5-16 x CTR) 2 (800A)		
2764			U4, Extremely Inverse 4.0		
2765			50G1P, (0.5-100 x CTR) 4 (1600A)		
2766			50G1D, (0.001 - 5s) 0.08 sec		
2767			Maint		
2768			51P1P 6 (2400A)		
2769			U3, Very Inverse 3.0		
2770			50P1P 10 (4000A)		
2771			50P1D 0.01 sec		
2772			Optical AF		
2773			50PAF 5 (2000A)		
2774			50PAFD (Standard) 7 ms		
2775					
2776	RL-MAIN-BUS B	SEL	Phase		
2777	Electronic	751A	51P1P, (0.5-16 x CTR) 6 (2400A)		
2778			U3, Very Inverse 3.0		
2779			50P1P, (0.5-100 x CTR) 20 (8000A)		
2780			50P1D, (0.001 - 5s) 0.02 sec		
2781			Ground		
2782			51G1P, (0.5-16 x CTR) 2 (800A)		
2783			U4, Extremely Inverse 4.0		
2784			50G1P, (0.5-100 x CTR) 4 (1600A)		
2785			50G1D, (0.001 - 5s) 0.08 sec		
2786			Maint		
2787			51P1P 6 (2400A)		
2788			U3, Very Inverse 3.0		
2789			50P1P 10 (4000A)		
2790			50P1D 0.01 sec		
2791			Optical AF		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2792			50PAF 5 (2000A)		
2793			50PAFD (Standard) 7 ms		
2794					
2795	RL-MV-ATS-CUP-CH-1A (F1)	SEL	Phase		
2796	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
2797			U4, Extremely Inverse 1.5		
2798			50P1P, (0.5-100 x CTR) 45 (5400A)		
2799			50P1D, (0.001 - 5s) 0.005 sec		
2800			Ground		
2801			51G1P, (0.5-16 x CTR) 2 (240A)		
2802			U4, Extremely Inverse 3.0		
2803			50G1P, (0.5-100 x CTR) 6 (720A)		
2804			50G1D, (0.001 - 5s) 0.25 sec		
2805					
2806	RL-MV-ATS-CUP-CH-1B (F1)	SEL	Phase		
2807	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
2808			U4, Extremely Inverse 3.0		
2809			50P1P, (0.5-100 x CTR) 45 (5400A)		
2810			50P1D, (0.001 - 5s) 0.005 sec		
2811			Ground		
2812			51G1P, (0.5-16 x CTR) 2 (240A)		
2813			U3, Very Inverse 3.0		
2814			50G1P, (0.5-100 x CTR) 10 (1200A)		
2815			50G1D, (0.001 - 5s) 0.4 sec		
2816					
2817	RL-MV-ATS-CUP-CH-2A (F3)	SEL	Phase		
2818	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
2819			U4, Extremely Inverse 3.0		
2820			50P1P, (0.5-100 x CTR) 45 (5400A)		
2821			50P1D, (0.001 - 5s) 0.005 sec		
2822			Ground		
2823			51G1P, (0.5-16 x CTR) 2 (240A)		
2824			U3, Very Inverse 3.0		
2825			50G1P, (0.5-100 x CTR) 10 (1200A)		
2826			50G1D, (0.001 - 5s) 0.4 sec		
2827					
2828	RL-MV-ATS-CUP-CH-2B (F3)	SEL	Phase		
2829	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
2830			U4, Extremely Inverse 3.0		
2831			50P1P, (0.5-100 x CTR) 45 (5400A)		
2832			50P1D, (0.001 - 5s) 0.005 sec		
2833			Ground		
2834			51G1P, (0.5-16 x CTR) 2 (240A)		
2835			U3, Very Inverse 3.0		
2836			50G1P, (0.5-100 x CTR) 10 (1200A)		
2837			50G1D, (0.001 - 5s) 0.4 sec		
2838					
2839	RL-MV-ATS-CUP-CH-A (50/51E1)	SEL	Phase		
2840	Electronic	751	51P1P 3.5 (840A)		
2841			U4, Extremely Inverse 3.0		
2842			50P1P 30 (7200A)		
2843			50P1D 0.01 sec		
2844			Ground		
2845			51G1P 1.5 (360A)		
2846			U4, Extremely Inverse 4.0		
2847			50G1P 4 (960A)		
2848			50G1D 0.3 sec		
2849			Maint		
2850			51P1P 3.5 (840A)		
2851			U4, Extremely Inverse 2.5		
2852			50P1P 10 (2400A)		
2853			50P1D 0.01 sec		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2854			Optical AF		
2855			50PAF 3 (720A)		
2856			50PAFD (Standard) 13 ms		
2857					
2858	RL-MV-ATS-CUP-CH-A (50/51E2)	SEL	Phase		
2859	Electronic	751	51P1P 3.5 (840A)		
2860			U4, Extremely Inverse 3.0		
2861			50P1P 30 (7200A)		
2862			50P1D 0.01 sec		
2863			Ground		
2864			51G1P 1.5 (360A)		
2865			U4, Extremely Inverse 4.0		
2866			50G1P 4 (960A)		
2867			50G1D 0.3 sec		
2868			Maint		
2869			51P1P 3.5 (840A)		
2870			U4, Extremely Inverse 2.5		
2871			50P1P 10 (2400A)		
2872			50P1D 0.01 sec		
2873			Optical AF		
2874			50PAF 3 (720A)		
2875			50PAFD (Standard) 13 ms		
2876					
2877	RL-MV-ATS-CUP-CH-A (50/51N1)	SEL	Phase		
2878	Electronic	751	51P1P 3.5 (840A)		
2879			U4, Extremely Inverse 3.0		
2880			50P1P 30 (7200A)		
2881			50P1D 0.01 sec		
2882			Ground		
2883			51G1P 1.5 (360A)		
2884			U4, Extremely Inverse 4.0		
2885			50G1P 4 (960A)		
2886			50G1D 0.3 sec		
2887			Maint		
2888			51P1P 3.5 (840A)		
2889			U4, Extremely Inverse 2.5		
2890			50P1P 10 (2400A)		
2891			50P1D 0.01 sec		
2892			Optical AF		
2893			50PAF 3 (720A)		
2894			50PAFD (Standard) 13 ms		
2895					
2896	RL-MV-ATS-CUP-CH-A (50/51N2)	SEL	Phase		
2897	Electronic	751	51P1P 3.5 (840A)		
2898			U4, Extremely Inverse 3.0		
2899			50P1P 30 (7200A)		
2900			50P1D 0.01 sec		
2901			Ground		
2902			51G1P 1.5 (360A)		
2903			U4, Extremely Inverse 4.0		
2904			50G1P 4 (960A)		
2905			50G1D 0.3 sec		
2906			Maint		
2907			51P1P 3.5 (840A)		
2908			U4, Extremely Inverse 2.5		
2909			50P1P 10 (2400A)		
2910			50P1D 0.01 sec		
2911			Optical AF		
2912			50PAF 3 (720A)		
2913			50PAFD (Standard) 13 ms		
2914					
2915	RL-MV-ATS-CUP-CH-A (F2)	SEL	Phase		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2916	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
2917			U4, Extremely Inverse 3.0		
2918			50P1P, (0.5-100 x CTR) 45 (5400A)		
2919			50P1D, (0.001 - 5s) 0.005 sec		
2920			Ground		
2921			51G1P, (0.5-16 x CTR) 2 (240A)		
2922			U3, Very Inverse 3.0		
2923			50G1P, (0.5-100 x CTR) 10 (1200A)		
2924			50G1D, (0.001 - 5s) 0.4 sec		
2925					
2926	RL-MV-ATS-CUP-CH-A (F4)	SEL	Phase		
2927	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
2928			U4, Extremely Inverse 3.0		
2929			50P1P, (0.5-100 x CTR) 45 (5400A)		
2930			50P1D, (0.001 - 5s) 0.005 sec		
2931			Ground		
2932			51G1P, (0.5-16 x CTR) 2 (240A)		
2933			U3, Very Inverse 3.0		
2934			50G1P, (0.5-100 x CTR) 10 (1200A)		
2935			50G1D, (0.001 - 5s) 0.4 sec		
2936					
2937	RL-MV-ATS-CUP-CH-B (50/51E1)	SEL	Phase		
2938	Electronic	751	51P1P 3.5 (840A)		
2939			U4, Extremely Inverse 3.0		
2940			50P1P 30 (7200A)		
2941			50P1D 0.01 sec		
2942			Ground		
2943			51G1P 1.5 (360A)		
2944			U4, Extremely Inverse 4.0		
2945			50G1P 4 (960A)		
2946			50G1D 0.3 sec		
2947			Maint		
2948			51P1P 3.5 (840A)		
2949			U4, Extremely Inverse 2.5		
2950			50P1P 10 (2400A)		
2951			50P1D 0.01 sec		
2952			Optical AF		
2953			50PAF 3 (720A)		
2954			50PAFD (Standard) 13 ms		
2955					
2956	RL-MV-ATS-CUP-CH-B (50/51E2)	SEL	Phase		
2957	Electronic	751	51P1P 3.5 (840A)		
2958			U4, Extremely Inverse 3.0		
2959			50P1P 30 (7200A)		
2960			50P1D 0.01 sec		
2961			Ground		
2962			51G1P 1.5 (360A)		
2963			U4, Extremely Inverse 4.0		
2964			50G1P 4 (960A)		
2965			50G1D 0.3 sec		
2966			Maint		
2967			51P1P 3.5 (840A)		
2968			U4, Extremely Inverse 2.5		
2969			50P1P 10 (2400A)		
2970			50P1D 0.01 sec		
2971			Optical AF		
2972			50PAF 3 (720A)		
2973			50PAFD (Standard) 13 ms		
2974					
2975	RL-MV-ATS-CUP-CH-B (50/51N1)	SEL	Phase		
2976	Electronic	751	51P1P 3.5 (840A)		
2977			U4, Extremely Inverse 3.0		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
2978			50P1P 30 (7200A)		
2979			50P1D 0.01 sec		
2980			Ground		
2981			51G1P 1.5 (360A)		
2982			U4, Extremely Inverse 4.0		
2983			50G1P 4 (960A)		
2984			50G1D 0.3 sec		
2985			Maint		
2986			51P1P 3.5 (840A)		
2987			U4, Extremely Inverse 2.5		
2988			50P1P 10 (2400A)		
2989			50P1D 0.01 sec		
2990			Optical AF		
2991			50PAF 3 (720A)		
2992			50PAFD (Standard) 13 ms		
2993					
2994	RL-MV-ATS-CUP-CH-B (50/51N2)	SEL	Phase		
2995	Electronic	751	51P1P 3.5 (840A)		
2996			U4, Extremely Inverse 3.0		
2997			50P1P 30 (7200A)		
2998			50P1D 0.01 sec		
2999			Ground		
3000			51G1P 1.5 (360A)		
3001			U4, Extremely Inverse 4.0		
3002			50G1P 4 (960A)		
3003			50G1D 0.3 sec		
3004			Maint		
3005			51P1P 3.5 (840A)		
3006			U4, Extremely Inverse 2.5		
3007			50P1P 10 (2400A)		
3008			50P1D 0.01 sec		
3009			Optical AF		
3010			50PAF 3 (720A)		
3011			50PAFD (Standard) 13 ms		
3012					
3013	RL-MV-ATS-CUP-CH-B (F2)	SEL	Phase		
3014	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
3015			U4, Extremely Inverse 3.0		
3016			50P1P, (0.5-100 x CTR) 45 (5400A)		
3017			50P1D, (0.001 - 5s) 0.005 sec		
3018			Ground		
3019			51G1P, (0.5-16 x CTR) 2 (240A)		
3020			U3, Very Inverse 3.0		
3021			50G1P, (0.5-100 x CTR) 10 (1200A)		
3022			50G1D, (0.001 - 5s) 0.4 sec		
3023					
3024	RL-MV-ATS-CUP-CH-B (F4)	SEL	Phase		
3025	Electronic	751	51P1P, (0.5-16 x CTR) 6 (720A)		
3026			U4, Extremely Inverse 3.0		
3027			50P1P, (0.5-100 x CTR) 45 (5400A)		
3028			50P1D, (0.001 - 5s) 0.005 sec		
3029			Ground		
3030			51G1P, (0.5-16 x CTR) 2 (240A)		
3031			U3, Very Inverse 3.0		
3032			50G1P, (0.5-100 x CTR) 10 (1200A)		
3033			50G1D, (0.001 - 5s) 0.4 sec		
3034					
3035	RL-MV-ATS-CUP-MECH-A (50/51E1)	SEL	Phase		
3036	Electronic	751	51P1P 3.5 (840A)		
3037			U4, Extremely Inverse 3.0		
3038			50P1P 30 (7200A)		
3039			50P1D 0.01 sec		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3040			Ground		
3041			51G1P 1.5 (360A)		
3042			U4, Extremely Inverse 4.0		
3043			50G1P 4 (960A)		
3044			50G1D 0.3 sec		
3045			Maint		
3046			51P1P 3.5 (840A)		
3047			U4, Extremely Inverse 2.5		
3048			50P1P 10 (2400A)		
3049			50P1D 0.01 sec		
3050			Optical AF		
3051			50PAF 3 (720A)		
3052			50PAFD (Standard) 13 ms		
3053					
3054	RL-MV-ATS-CUP-MECH-A (50/51E2)	SEL	Phase		
3055	Electronic	751	51P1P 3.5 (840A)		
3056			U4, Extremely Inverse 3.0		
3057			50P1P 30 (7200A)		
3058			50P1D 0.01 sec		
3059			Ground		
3060			51G1P 1.5 (360A)		
3061			U4, Extremely Inverse 4.0		
3062			50G1P 4 (960A)		
3063			50G1D 0.3 sec		
3064			Maint		
3065			51P1P 3.5 (840A)		
3066			U4, Extremely Inverse 2.5		
3067			50P1P 10 (2400A)		
3068			50P1D 0.01 sec		
3069			Optical AF		
3070			50PAF 3 (720A)		
3071			50PAFD (Standard) 13 ms		
3072					
3073	RL-MV-ATS-CUP-MECH-A (50/51N1)	SEL	Phase		
3074	Electronic	751	51P1P 3.5 (840A)		
3075			U4, Extremely Inverse 3.0		
3076			50P1P 30 (7200A)		
3077			50P1D 0.01 sec		
3078			Ground		
3079			51G1P 1.5 (360A)		
3080			U4, Extremely Inverse 4.0		
3081			50G1P 4 (960A)		
3082			50G1D 0.3 sec		
3083			Maint		
3084			51P1P 3.5 (840A)		
3085			U4, Extremely Inverse 2.5		
3086			50P1P 10 (2400A)		
3087			50P1D 0.01 sec		
3088			Optical AF		
3089			50PAF 3 (720A)		
3090			50PAFD (Standard) 13 ms		
3091					
3092	RL-MV-ATS-CUP-MECH-A (50/51N2)	SEL	Phase		
3093	Electronic	751	51P1P 3.5 (840A)		
3094			U4, Extremely Inverse 3.0		
3095			50P1P 30 (7200A)		
3096			50P1D 0.01 sec		
3097			Ground		
3098			51G1P 1.5 (360A)		
3099			U4, Extremely Inverse 4.0		
3100			50G1P 4 (960A)		
3101			50G1D 0.3 sec		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3102			Maint		
3103			51P1P 3.5 (840A)		
3104			U4, Extremely Inverse 2.5		
3105			50P1P 10 (2400A)		
3106			50P1D 0.01 sec		
3107			Optical AF		
3108			50PAF 3 (720A)		
3109			50PAFD (Standard) 13 ms		
3110					
3111	RL-MV-ATS-CUP-MECH-A (F1)	SEL	Phase		
3112	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3113			U3, Very Inverse 3.0		
3114			50P1P, (0.5-100 x CTR) 10 (800A)		
3115			50P1D, (0.001 - 5s) 0.001 sec		
3116			Ground		
3117			51G1P, (0.5-16 x CTR) 6 (480A)		
3118			U3, Very Inverse 3.0		
3119			50G1P, (0.5-100 x CTR) 10 (800A)		
3120			50G1D, (0.001 - 5s) 0.001 sec		
3121					
3122	RL-MV-ATS-CUP-MECH-A (F2)	SEL	Phase		
3123	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3124			U3, Very Inverse 3.0		
3125			50P1P, (0.5-100 x CTR) 10 (800A)		
3126			50P1D, (0.001 - 5s) 0.001 sec		
3127			Ground		
3128			51G1P, (0.5-16 x CTR) 6 (480A)		
3129			U3, Very Inverse 3.0		
3130			50G1P, (0.5-100 x CTR) 10 (800A)		
3131			50G1D, (0.001 - 5s) 0.001 sec		
3132					
3133	RL-MV-ATS-CUP-MECH-A (F3)	SEL	Phase		
3134	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3135			U3, Very Inverse 3.0		
3136			50P1P, (0.5-100 x CTR) 10 (800A)		
3137			50P1D, (0.001 - 5s) 0.001 sec		
3138			Ground		
3139			51G1P, (0.5-16 x CTR) 6 (480A)		
3140			U3, Very Inverse 3.0		
3141			50G1P, (0.5-100 x CTR) 10 (800A)		
3142			50G1D, (0.001 - 5s) 0.001 sec		
3143					
3144	RL-MV-ATS-CUP-MECH-A (F4)	SEL	Phase		
3145	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3146			U3, Very Inverse 3.0		
3147			50P1P, (0.5-100 x CTR) 10 (800A)		
3148			50P1D, (0.001 - 5s) 0.001 sec		
3149			Ground		
3150			51G1P, (0.5-16 x CTR) 6 (480A)		
3151			U3, Very Inverse 3.0		
3152			50G1P, (0.5-100 x CTR) 10 (800A)		
3153			50G1D, (0.001 - 5s) 0.001 sec		
3154					
3155	RL-MV-ATS-CUP-MECH-B (50/51E1)	SEL	Phase		
3156	Electronic	751	51P1P 3.5 (840A)		
3157			U4, Extremely Inverse 3.0		
3158			50P1P 30 (7200A)		
3159			50P1D 0.01 sec		
3160			Ground		
3161			51G1P 1.5 (360A)		
3162			U4, Extremely Inverse 4.0		
3163			50G1P 4 (960A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3164			50G1D 0.3 sec		
3165			Maint		
3166			51P1P 3.5 (840A)		
3167			U4, Extremely Inverse 2.5		
3168			50P1P 10 (2400A)		
3169			50P1D 0.01 sec		
3170			Optical AF		
3171			50PAF 3 (720A)		
3172			50PAFD (Standard) 13 ms		
3173					
3174	RL-MV-ATS-CUP-MECH-B (50/51E2)	SEL	Phase		
3175	Electronic	751	51P1P 3.5 (840A)		
3176			U4, Extremely Inverse 3.0		
3177			50P1P 30 (7200A)		
3178			50P1D 0.01 sec		
3179			Ground		
3180			51G1P 1.5 (360A)		
3181			U4, Extremely Inverse 4.0		
3182			50G1P 4 (960A)		
3183			50G1D 0.3 sec		
3184			Maint		
3185			51P1P 3.5 (840A)		
3186			U4, Extremely Inverse 2.5		
3187			50P1P 10 (2400A)		
3188			50P1D 0.01 sec		
3189			Optical AF		
3190			50PAF 3 (720A)		
3191			50PAFD (Standard) 13 ms		
3192					
3193	RL-MV-ATS-CUP-MECH-B (50/51N1)	SEL	Phase		
3194	Electronic	751	51P1P 3.5 (840A)		
3195			U4, Extremely Inverse 3.0		
3196			50P1P 30 (7200A)		
3197			50P1D 0.01 sec		
3198			Ground		
3199			51G1P 1.5 (360A)		
3200			U4, Extremely Inverse 4.0		
3201			50G1P 4 (960A)		
3202			50G1D 0.3 sec		
3203			Maint		
3204			51P1P 3.5 (840A)		
3205			U4, Extremely Inverse 2.5		
3206			50P1P 10 (2400A)		
3207			50P1D 0.01 sec		
3208			Optical AF		
3209			50PAF 3 (720A)		
3210			50PAFD (Standard) 13 ms		
3211					
3212	RL-MV-ATS-CUP-MECH-B (50/51N2)	SEL	Phase		
3213	Electronic	751	51P1P 3.5 (840A)		
3214			U4, Extremely Inverse 3.0		
3215			50P1P 30 (7200A)		
3216			50P1D 0.01 sec		
3217			Ground		
3218			51G1P 1.5 (360A)		
3219			U4, Extremely Inverse 4.0		
3220			50G1P 4 (960A)		
3221			50G1D 0.3 sec		
3222			Maint		
3223			51P1P 3.5 (840A)		
3224			U4, Extremely Inverse 2.5		
3225			50P1P 10 (2400A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3226			50P1D 0.01 sec		
3227			Optical AF		
3228			50PAF 3 (720A)		
3229			50PAFD (Standard) 13 ms		
3230					
3231	RL-MV-ATS-CUP-MECH-B (F1)	SEL	Phase		
3232	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3233			U3, Very Inverse 3.0		
3234			50P1P, (0.5-100 x CTR) 10 (800A)		
3235			50P1D, (0.001 - 5s) 0.001 sec		
3236			Ground		
3237			51G1P, (0.5-16 x CTR) 6 (480A)		
3238			U3, Very Inverse 3.0		
3239			50G1P, (0.5-100 x CTR) 10 (800A)		
3240			50G1D, (0.001 - 5s) 0.001 sec		
3241					
3242	RL-MV-ATS-CUP-MECH-B (F2)	SEL	Phase		
3243	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3244			U3, Very Inverse 3.0		
3245			50P1P, (0.5-100 x CTR) 10 (800A)		
3246			50P1D, (0.001 - 5s) 0.001 sec		
3247			Ground		
3248			51G1P, (0.5-16 x CTR) 6 (480A)		
3249			U3, Very Inverse 3.0		
3250			50G1P, (0.5-100 x CTR) 10 (800A)		
3251			50G1D, (0.001 - 5s) 0.001 sec		
3252					
3253	RL-MV-ATS-CUP-MECH-B (F3)	SEL	Phase		
3254	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3255			U3, Very Inverse 3.0		
3256			50P1P, (0.5-100 x CTR) 10 (800A)		
3257			50P1D, (0.001 - 5s) 0.001 sec		
3258			Ground		
3259			51G1P, (0.5-16 x CTR) 6 (480A)		
3260			U3, Very Inverse 3.0		
3261			50G1P, (0.5-100 x CTR) 10 (800A)		
3262			50G1D, (0.001 - 5s) 0.001 sec		
3263					
3264	RL-MV-ATS-CUP-MECH-B (F4)	SEL	Phase		
3265	Electronic	751	51P1P, (0.5-16 x CTR) 6 (480A)		
3266			U3, Very Inverse 3.0		
3267			50P1P, (0.5-100 x CTR) 10 (800A)		
3268			50P1D, (0.001 - 5s) 0.001 sec		
3269			Ground		
3270			51G1P, (0.5-16 x CTR) 6 (480A)		
3271			U3, Very Inverse 3.0		
3272			50G1P, (0.5-100 x CTR) 10 (800A)		
3273			50G1D, (0.001 - 5s) 0.001 sec		
3274					
3275	RL-MV-ATS-IUH-EQ-A (50/51E1)	SEL	Phase		
3276	Electronic	751	51P1P 3.5 (840A)		
3277			U4, Extremely Inverse 3.0		
3278			50P1P 30 (7200A)		
3279			50P1D 0.01 sec		
3280			Ground		
3281			51G1P 1.5 (360A)		
3282			U4, Extremely Inverse 4.0		
3283			50G1P 4 (960A)		
3284			50G1D 0.3 sec		
3285			Maint		
3286			51P1P 3.5 (840A)		
3287			U4, Extremely Inverse 2.5		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3288			50P1P 10 (2400A)		
3289			50P1D 0.01 sec		
3290			Optical AF		
3291			50PAF 3 (720A)		
3292			50PAFD (Standard) 13 ms		
3293					
3294	RL-MV-ATS-IUH-EQ-A (50/51E2)	SEL	Phase		
3295	Electronic	751	51P1P 3.5 (840A)		
3296			U4, Extremely Inverse 3.0		
3297			50P1P 30 (7200A)		
3298			50P1D 0.01 sec		
3299			Ground		
3300			51G1P 1.5 (360A)		
3301			U4, Extremely Inverse 4.0		
3302			50G1P 4 (960A)		
3303			50G1D 0.3 sec		
3304			Maint		
3305			51P1P 3.5 (840A)		
3306			U4, Extremely Inverse 2.5		
3307			50P1P 10 (2400A)		
3308			50P1D 0.01 sec		
3309			Optical AF		
3310			50PAF 3 (720A)		
3311			50PAFD (Standard) 13 ms		
3312					
3313	RL-MV-ATS-IUH-EQ-A (50/51N1)	SEL	Phase		
3314	Electronic	751	51P1P 3.5 (840A)		
3315			U4, Extremely Inverse 3.0		
3316			50P1P 30 (7200A)		
3317			50P1D 0.01 sec		
3318			Ground		
3319			51G1P 1.5 (360A)		
3320			U4, Extremely Inverse 4.0		
3321			50G1P 4 (960A)		
3322			50G1D 0.3 sec		
3323			Maint		
3324			51P1P 3.5 (840A)		
3325			U4, Extremely Inverse 2.5		
3326			50P1P 10 (2400A)		
3327			50P1D 0.01 sec		
3328			Optical AF		
3329			50PAF 3 (720A)		
3330			50PAFD (Standard) 13 ms		
3331					
3332	RL-MV-ATS-IUH-EQ-A (50/51N2)	SEL	Phase		
3333	Electronic	751	51P1P 3.5 (840A)		
3334			U4, Extremely Inverse 3.0		
3335			50P1P 30 (7200A)		
3336			50P1D 0.01 sec		
3337			Ground		
3338			51G1P 1.5 (360A)		
3339			U4, Extremely Inverse 4.0		
3340			50G1P 4 (960A)		
3341			50G1D 0.3 sec		
3342			Maint		
3343			51P1P 3.5 (840A)		
3344			U4, Extremely Inverse 2.5		
3345			50P1P 10 (2400A)		
3346			50P1D 0.01 sec		
3347			Optical AF		
3348			50PAF 3 (720A)		
3349			50PAFD (Standard) 13 ms		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3350					
3351	RL-MV-ATS-IUH-EQ-A (F1)	SEL	Phase		
3352	Electronic	751	51P1P, (0.5-16 x CTR) 6 (960A)		
3353			U3, Very Inverse 3.0		
3354			50P1P, (0.5-100 x CTR) 10 (1600A)		
3355			50P1D, (0.001 - 5s) 0.001 sec		
3356			Ground		
3357			51N1P, (0.5-16 x CTR) 6 (960A)		
3358			U3, Very Inverse 3.0		
3359			50N1P, (0.5-100 x CTR) 10 (1600A)		
3360			50N1D, (0.001 - 5s) 0.001 sec		
3361					
3362	RL-MV-ATS-IUH-EQ-A (F2)	SEL	Phase		
3363	Electronic	751	51P1P, (0.5-16 x CTR) 6 (960A)		
3364			U3, Very Inverse 3.0		
3365			50P1P, (0.5-100 x CTR) 10 (1600A)		
3366			50P1D, (0.001 - 5s) 0.001 sec		
3367			Ground		
3368			51N1P, (0.5-16 x CTR) 6 (960A)		
3369			U3, Very Inverse 3.0		
3370			50N1P, (0.5-100 x CTR) 10 (1600A)		
3371			50N1D, (0.001 - 5s) 0.001 sec		
3372					
3373	RL-MV-ATS-IUH-EQ-B (50/51E1)	SEL	Phase		
3374	Electronic	751	51P1P 3.5 (840A)		
3375			U4, Extremely Inverse 3.0		
3376			50P1P 30 (7200A)		
3377			50P1D 0.01 sec		
3378			Ground		
3379			51G1P 1.5 (360A)		
3380			U4, Extremely Inverse 4.0		
3381			50G1P 4 (960A)		
3382			50G1D 0.3 sec		
3383			Maint		
3384			51P1P 3.5 (840A)		
3385			U4, Extremely Inverse 2.5		
3386			50P1P 10 (2400A)		
3387			50P1D 0.01 sec		
3388			Optical AF		
3389			50PAF 3 (720A)		
3390			50PAFD (Standard) 13 ms		
3391					
3392	RL-MV-ATS-IUH-EQ-B (50/51E2)	SEL	Phase		
3393	Electronic	751	51P1P 3.5 (840A)		
3394			U4, Extremely Inverse 3.0		
3395			50P1P 30 (7200A)		
3396			50P1D 0.01 sec		
3397			Ground		
3398			51G1P 1.5 (360A)		
3399			U4, Extremely Inverse 4.0		
3400			50G1P 4 (960A)		
3401			50G1D 0.3 sec		
3402			Maint		
3403			51P1P 3.5 (840A)		
3404			U4, Extremely Inverse 2.5		
3405			50P1P 10 (2400A)		
3406			50P1D 0.01 sec		
3407			Optical AF		
3408			50PAF 3 (720A)		
3409			50PAFD (Standard) 13 ms		
3410					
3411	RL-MV-ATS-IUH-EQ-B (50/51N1)	SEL	Phase		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3412	Electronic	751	51P1P 3.5 (840A)		
3413			U4, Extremely Inverse 3.0		
3414			50P1P 30 (7200A)		
3415			50P1D 0.01 sec		
3416			Ground		
3417			51G1P 1.5 (360A)		
3418			U4, Extremely Inverse 4.0		
3419			50G1P 4 (960A)		
3420			50G1D 0.3 sec		
3421			Maint		
3422			51P1P 3.5 (840A)		
3423			U4, Extremely Inverse 2.5		
3424			50P1P 10 (2400A)		
3425			50P1D 0.01 sec		
3426			Optical AF		
3427			50PAF 3 (720A)		
3428			50PAFD (Standard) 13 ms		
3429					
3430	RL-MV-ATS-IUH-EQ-B (50/51N2)	SEL	Phase		
3431	Electronic	751	51P1P 3.5 (840A)		
3432			U4, Extremely Inverse 3.0		
3433			50P1P 30 (7200A)		
3434			50P1D 0.01 sec		
3435			Ground		
3436			51G1P 1.5 (360A)		
3437			U4, Extremely Inverse 4.0		
3438			50G1P 4 (960A)		
3439			50G1D 0.3 sec		
3440			Maint		
3441			51P1P 3.5 (840A)		
3442			U4, Extremely Inverse 2.5		
3443			50P1P 10 (2400A)		
3444			50P1D 0.01 sec		
3445			Optical AF		
3446			50PAF 3 (720A)		
3447			50PAFD (Standard) 13 ms		
3448					
3449	RL-MV-ATS-IUH-EQ-B (F1)	SEL	Phase		
3450	Electronic	751	51P1P 0.5 (80A)		
3451			U3, Very Inverse 2.0		
3452			50P1P 15 (2400A)		
3453			50P1D 0.02 sec		
3454			Ground		
3455			51N1P 2 (320A)		
3456			U3, Very Inverse 2.0		
3457			50N1P 15 (2400A)		
3458			50N1D 0.02 sec		
3459					
3460	RL-MV-ATS-IUH-EQ-B (F2)	SEL	Phase		
3461	Electronic	751	51P1P, (0.5-16 x CTR) 2 (320A)		
3462			U3, Very Inverse 2.0		
3463			50P1P, (0.5-100 x CTR) 15 (2400A)		
3464			50P1D, (0.001 - 5s) 0.02 sec		
3465			Ground		
3466			51N1P, (0.5-16 x CTR) 2 (320A)		
3467			U3, Very Inverse 2.0		
3468			50N1P, (0.5-100 x CTR) 15 (2400A)		
3469			50N1D, (0.001 - 5s) 0.02 sec		
3470					
3471	RL-MV-ATS-IUH-OS-A (50/51E1)	SEL	Phase		
3472	Electronic	751	51P1P 3.5 (840A)		
3473			U4, Extremely Inverse 3.0		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3474			50P1P 30 (7200A)		
3475			50P1D 0.01 sec		
3476			Ground		
3477			51G1P 1.5 (360A)		
3478			U4, Extremely Inverse 4.0		
3479			50G1P 4 (960A)		
3480			50G1D 0.3 sec		
3481			Maint		
3482			51P1P 3.5 (840A)		
3483			U4, Extremely Inverse 2.5		
3484			50P1P 10 (2400A)		
3485			50P1D 0.01 sec		
3486			Optical AF		
3487			50PAF 3 (720A)		
3488			50PAFD (Standard) 13 ms		
3489					
3490	RL-MV-ATS-IUH-OS-A (50/51E2)	SEL	Phase		
3491	Electronic	751	51P1P 3.5 (840A)		
3492			U4, Extremely Inverse 3.0		
3493			50P1P 30 (7200A)		
3494			50P1D 0.01 sec		
3495			Ground		
3496			51G1P 1.5 (360A)		
3497			U4, Extremely Inverse 4.0		
3498			50G1P 4 (960A)		
3499			50G1D 0.3 sec		
3500			Maint		
3501			51P1P 3.5 (840A)		
3502			U4, Extremely Inverse 2.5		
3503			50P1P 10 (2400A)		
3504			50P1D 0.01 sec		
3505			Optical AF		
3506			50PAF 3 (720A)		
3507			50PAFD (Standard) 13 ms		
3508					
3509	RL-MV-ATS-IUH-OS-A (50/51N1)	SEL	Phase		
3510	Electronic	751	51P1P 3.5 (840A)		
3511			U4, Extremely Inverse 3.0		
3512			50P1P 30 (7200A)		
3513			50P1D 0.01 sec		
3514			Ground		
3515			51G1P 1.5 (360A)		
3516			U4, Extremely Inverse 4.0		
3517			50G1P 4 (960A)		
3518			50G1D 0.3 sec		
3519			Maint		
3520			51P1P 3.5 (840A)		
3521			U4, Extremely Inverse 2.5		
3522			50P1P 10 (2400A)		
3523			50P1D 0.01 sec		
3524			Optical AF		
3525			50PAF 3 (720A)		
3526			50PAFD (Standard) 13 ms		
3527					
3528	RL-MV-ATS-IUH-OS-A (50/51N2)	SEL	Phase		
3529	Electronic	751	51P1P 3.5 (840A)		
3530			U4, Extremely Inverse 3.0		
3531			50P1P 30 (7200A)		
3532			50P1D 0.01 sec		
3533			Ground		
3534			51G1P 1.5 (360A)		
3535			U4, Extremely Inverse 4.0		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3536			50G1P 4 (960A)		
3537			50G1D 0.3 sec		
3538			Maint		
3539			51P1P 3.5 (840A)		
3540			U4, Extremely Inverse 2.5		
3541			50P1P 10 (2400A)		
3542			50P1D 0.01 sec		
3543			Optical AF		
3544			50PAF 3 (720A)		
3545			50PAFD (Standard) 13 ms		
3546					
3547	RL-MV-ATS-IUH-OS-A (F1)	SEL	Phase		
3548	Electronic	751	51P1P, (0.5-16 x CTR) 6 (960A)		
3549			U3, Very Inverse 3.0		
3550			50P1P, (0.5-100 x CTR) 10 (1600A)		
3551			50P1D, (0.001 - 5s) 0.001 sec		
3552			Ground		
3553			51N1P, (0.5-16 x CTR) 6 (960A)		
3554			U3, Very Inverse 3.0		
3555			50N1P, (0.5-100 x CTR) 10 (1600A)		
3556			50N1D, (0.001 - 5s) 0.001 sec		
3557					
3558	RL-MV-ATS-IUH-OS-A (F2)	SEL	Phase		
3559	Electronic	751	51P1P, (0.5-16 x CTR) 6 (960A)		
3560			U3, Very Inverse 3.0		
3561			50P1P, (0.5-100 x CTR) 10 (1600A)		
3562			50P1D, (0.001 - 5s) 0.001 sec		
3563			Ground		
3564			51N1P, (0.5-16 x CTR) 6 (960A)		
3565			U3, Very Inverse 3.0		
3566			50N1P, (0.5-100 x CTR) 10 (1600A)		
3567			50N1D, (0.001 - 5s) 0.001 sec		
3568					
3569	RL-MV-ATS-IUH-OS-B (50/51E1)	SEL	Phase		
3570	Electronic	751	51P1P 3.5 (840A)		
3571			U4, Extremely Inverse 3.0		
3572			50P1P 30 (7200A)		
3573			50P1D 0.01 sec		
3574			Ground		
3575			51G1P 1.5 (360A)		
3576			U4, Extremely Inverse 4.0		
3577			50G1P 4 (960A)		
3578			50G1D 0.3 sec		
3579			Maint		
3580			51P1P 3.5 (840A)		
3581			U4, Extremely Inverse 2.5		
3582			50P1P 10 (2400A)		
3583			50P1D 0.01 sec		
3584			Optical AF		
3585			50PAF 3 (720A)		
3586			50PAFD (Standard) 13 ms		
3587					
3588	RL-MV-ATS-IUH-OS-B (50/51E2)	SEL	Phase		
3589	Electronic	751	51P1P 3.5 (840A)		
3590			U4, Extremely Inverse 3.0		
3591			50P1P 30 (7200A)		
3592			50P1D 0.01 sec		
3593			Ground		
3594			51G1P 1.5 (360A)		
3595			U4, Extremely Inverse 4.0		
3596			50G1P 4 (960A)		
3597			50G1D 0.3 sec		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3598			Maint		
3599			51P1P 3.5 (840A)		
3600			U4, Extremely Inverse 2.5		
3601			50P1P 10 (2400A)		
3602			50P1D 0.01 sec		
3603			Optical AF		
3604			50PAF 3 (720A)		
3605			50PAFD (Standard) 13 ms		
3606					
3607	RL-MV-ATS-IUH-OS-B (50/51N1)	SEL	Phase		
3608	Electronic	751	51P1P 3.5 (840A)		
3609			U4, Extremely Inverse 3.0		
3610			50P1P 30 (7200A)		
3611			50P1D 0.01 sec		
3612			Ground		
3613			51G1P 1.5 (360A)		
3614			U4, Extremely Inverse 4.0		
3615			50G1P 4 (960A)		
3616			50G1D 0.3 sec		
3617			Maint		
3618			51P1P 3.5 (840A)		
3619			U4, Extremely Inverse 2.5		
3620			50P1P 10 (2400A)		
3621			50P1D 0.01 sec		
3622			Optical AF		
3623			50PAF 3 (720A)		
3624			50PAFD (Standard) 13 ms		
3625					
3626	RL-MV-ATS-IUH-OS-B (50/51N2)	SEL	Phase		
3627	Electronic	751	51P1P 3.5 (840A)		
3628			U4, Extremely Inverse 3.0		
3629			50P1P 30 (7200A)		
3630			50P1D 0.01 sec		
3631			Ground		
3632			51G1P 1.5 (360A)		
3633			U4, Extremely Inverse 4.0		
3634			50G1P 4 (960A)		
3635			50G1D 0.3 sec		
3636			Maint		
3637			51P1P 3.5 (840A)		
3638			U4, Extremely Inverse 2.5		
3639			50P1P 10 (2400A)		
3640			50P1D 0.01 sec		
3641			Optical AF		
3642			50PAF 3 (720A)		
3643			50PAFD (Standard) 13 ms		
3644					
3645	RL-MV-ATS-IUH-OS-B (F1)	SEL	Phase		
3646	Electronic	751	51P1P, (0.5-16 x CTR) 6 (960A)		
3647			U3, Very Inverse 3.0		
3648			50P1P, (0.5-100 x CTR) 10 (1600A)		
3649			50P1D, (0.001 - 5s) 0.001 sec		
3650			Ground		
3651			51N1P, (0.5-16 x CTR) 6 (960A)		
3652			U3, Very Inverse 3.0		
3653			50N1P, (0.5-100 x CTR) 10 (1600A)		
3654			50N1D, (0.001 - 5s) 0.001 sec		
3655					
3656	RL-MV-ATS-IUH-OS-B (F2)	SEL	Phase		
3657	Electronic	751	51P1P, (0.5-16 x CTR) 6 (960A)		
3658			U3, Very Inverse 3.0		
3659			50P1P, (0.5-100 x CTR) 10 (1600A)		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3660			50P1D, (0.001 - 5s) 0.001 sec		
3661			Ground		
3662			51N1P, (0.5-16 x CTR) 6 (960A)		
3663			U3, Very Inverse 3.0		
3664			50N1P, (0.5-100 x CTR) 10 (1600A)		
3665			50N1D, (0.001 - 5s) 0.001 sec		
3666					
3667	**HV Fuses**				
3668	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3669	PDF-ESS-CUP	EATON/CUTLER-HAMMER	125.0A	Interrupting 50.0	125.0 Amps
3670		HLE, 15.5kV E-Rated	125.0A		
3671					
3672	PDF-USS-CH1-BUS A	EATON/CUTLER-HAMMER	540.0A	Interrupting 36.0	540.0 Amps
3673		RBA, RDB-800, 4.16-34.5kV E-Rated	540.0A		
3674					
3675	PDF-USS-CH1-BUS B	EATON/CUTLER-HAMMER	540.0A	Interrupting 36.0	540.0 Amps
3676		RBA, RDB-800, 4.16-34.5kV E-Rated	540.0A		
3677					
3678	PDF-USS-CH2-BUS A	EATON/CUTLER-HAMMER	540.0A	Interrupting 36.0	540.0 Amps
3679		RBA, RDB-800, 4.16-34.5kV E-Rated	540.0A		
3680					
3681	PDF-USS-CH2-BUS B	EATON/CUTLER-HAMMER	540.0A	Interrupting 36.0	540.0 Amps
3682		RBA, RDB-800, 4.16-34.5kV E-Rated	540.0A		
3683					
3684	PDF-USS-MECH1-BUS A	CUTLER-HAMMER	200.0A	Interrupting 65.0	200E
3685		BHLE, 15.5kV E-Rated	200.0A		
3686					
3687	PDF-USS-MECH1-BUS B	CUTLER-HAMMER	200.0A	Interrupting 65.0	200E
3688		BHLE, 15.5kV E-Rated	200.0A		
3689					
3690	PDF-USS-MECH2-BUS A	CUTLER-HAMMER	200.0A	Interrupting 65.0	200E
3691		BHLE, 15.5kV E-Rated	200.0A		
3692					
3693	PDF-USS-MECH2-BUS B	CUTLER-HAMMER	200.0A	Interrupting 65.0	200E
3694		BHLE, 15.5kV E-Rated	200.0A		
3695					
3696	Switches				
3697	Name/Type	Description	SC Ratings(kA)		
3698	ATS-EL1 (EMRG BYPASS)	Interrupting 0.0			
3699	Load Break Switch				
3700					
3701	ATS-EL1 (NORM BYPASS)	Interrupting 0.0			
3702	Load Break Switch				
3703					
3704	ATS-EQ1 (EMRG BYPASS)	Interrupting 0.0			
3705	Load Break Switch				
3706					
3707	ATS-EQ1 (NORM BYPASS)	Interrupting 0.0			
3708	Load Break Switch				
3709					
3710	ATS-GEN1 (EMRG BYPASS)	Interrupting 0.0			
3711	Load Break Switch				
3712					
3713	ATS-GEN1 (NORM BYPASS)	Interrupting 0.0			
3714	Load Break Switch				
3715					
3716	ATS-LS1 (EMRG BYPASS)	Interrupting 0.0			
3717	Load Break Switch				
3718					
3719	ATS-LS1 (NORM BYPASS)	Interrupting 0.0			
3720	Load Break Switch				
3721					

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3722	PD-DISC-CC-SS-FLTR-1	Interrupting 0.0			
3723	Load Break Switch				
3724					
3725	PD-DISC-CHWP-1	Interrupting 0.0			
3726	Load Break Switch				
3727					
3728	PD-DISC-CHWP-2	Interrupting 0.0			
3729	Load Break Switch				
3730					
3731	PD-DISC-CHWP-3	Interrupting 0.0			
3732	Load Break Switch				
3733					
3734	PD-DISC-CHWP-4	Interrupting 0.0			
3735	Load Break Switch				
3736					
3737	PD-DISC-CHWP-5	Interrupting 0.0			
3738	Load Break Switch				
3739					
3740	PD-DISC-CHWP-6	Interrupting 0.0			
3741	Load Break Switch				
3742					
3743	PD-DISC-CHWP-7	Interrupting 0.0			
3744	Load Break Switch				
3745					
3746	PD-DISC-CT-1	Interrupting 0.0			
3747	Load Break Switch				
3748					
3749	PD-DISC-CT-3	Interrupting 0.0			
3750	Load Break Switch				
3751					
3752	PD-DISC-CT-5	Interrupting 0.0			
3753	Load Break Switch				
3754					
3755	PD-DISC-CT-BASIN-SWP-FLTR-1	Interrupting 0.0			
3756	Load Break Switch				
3757					
3758	PD-DISC-CTF-2	Interrupting 0.0			
3759	Load Break Switch				
3760					
3761	PD-DISC-CTF-4	Interrupting 0.0			
3762	Load Break Switch				
3763					
3764	PD-DISC-CTF-6	Interrupting 0.0			
3765	Load Break Switch				
3766					
3767	PD-DISC-CTP-1	Interrupting 0.0			
3768	Load Break Switch				
3769					
3770	PD-DISC-CTP-2	Interrupting 0.0			
3771	Load Break Switch				
3772					
3773	PD-DISC-CTP-3	Interrupting 0.0			
3774	Load Break Switch				
3775					
3776	PD-DISC-CTP-4	Interrupting 0.0			
3777	Load Break Switch				
3778					
3779	PD-DISC-CTP-5	Interrupting 0.0			
3780	Load Break Switch				
3781					
3782	PD-DISC-CTP-6	Interrupting 0.0			
3783	Load Break Switch				

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3784					
3785	PD-DISC-HHW-FILTER	Interrupting 0.0			
3786	Load Break Switch				
3787					
3788	PD-DISC-HHWP-1	Interrupting 0.0			
3789	Load Break Switch				
3790					
3791	PD-DISC-HHWP-2	Interrupting 0.0			
3792	Load Break Switch				
3793					
3794	PD-DISC-HHWP-4	Interrupting 0.0			
3795	Load Break Switch				
3796					
3797	PD-DISC-HHWP-6	Interrupting 0.0			
3798	Load Break Switch				
3799					
3800	PD-DISC-HHWP3	Interrupting 0.0			
3801	Load Break Switch				
3802					
3803	PD-DISC-HHWP5	Interrupting 0.0			
3804	Load Break Switch				
3805					
3806	PD-DISC-HRC CHWP2	Interrupting 0.0			
3807	Load Break Switch				
3808					
3809	PD-DISC-HRC CHWP4	Interrupting 0.0			
3810	Load Break Switch				
3811					
3812	PD-DISC-HRC HHWP2	Interrupting 0.0			
3813	Load Break Switch				
3814					
3815	PD-DISC-HRC HHWP4	Interrupting 0.0			
3816	Load Break Switch				
3817					
3818	PD-DISC-HRCWP-1	Interrupting 0.0			
3819	Load Break Switch				
3820					
3821	PD-DISC-HRCWP-3	Interrupting 0.0			
3822	Load Break Switch				
3823					
3824	PD-DISC-HRHHWP-1	Interrupting 0.0			
3825	Load Break Switch				
3826					
3827	PD-DISC-HRHHWP-3	Interrupting 0.0			
3828	Load Break Switch				
3829					
3830	PD-ESS-CUP-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3831	Load Break Switch	MVS			
3832					
3833	PD-USS-CH1-BUS A-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3834	Load Break Switch	MVS			
3835					
3836	PD-USS-CH1-BUS A-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3837	Load Break Switch	MVS			
3838					
3839	PD-USS-CH1-BUS B-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3840	Load Break Switch	MVS			
3841					
3842	PD-USS-CH1-BUS B-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3843	Load Break Switch	MVS			
3844					
3845	PD-USS-CH2-BUS A-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		

	A	B	C	D	E
7	Name/Type	Description	Frame/Sensor/Plug	SC Ratings(kA)	Settings
3846	Load Break Switch	MVS			
3847					
3848	PD-USS-CH2-BUS A-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3849	Load Break Switch	MVS			
3850					
3851	PD-USS-CH2-BUS B-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3852	Load Break Switch	MVS			
3853					
3854	PD-USS-CH2-BUS B-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3855	Load Break Switch	MVS			
3856					
3857	PD-USS-MECH1-BUS A-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3858	Load Break Switch	MVS			
3859					
3860	PD-USS-MECH1-BUS A-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3861	Load Break Switch	MVS			
3862					
3863	PD-USS-MECH1-BUS B-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3864	Load Break Switch	MVS			
3865					
3866	PD-USS-MECH1-BUS B-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3867	Load Break Switch	MVS			
3868					
3869	PD-USS-MECH2-BUS A-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3870	Load Break Switch	MVS			
3871					
3872	PD-USS-MECH2-BUS A-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3873	Load Break Switch	MVS			
3874					
3875	PD-USS-MECH2-BUS B-KEY 1	EATON/CUTLER-HAMMER	Interrupting 25.0		
3876	Load Break Switch	MVS			
3877					
3878	PD-USS-MECH2-BUS B-KEY 2	EATON/CUTLER-HAMMER	Interrupting 25.0		
3879	Load Break Switch	MVS			

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller.

1.3 SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

D. Seismic Qualification Data: Certificates, for each VFC, accessories, and components, from manufacturer.

1. Certificate of compliance.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

E. Product Certificates: For each VFC from manufacturer.

F. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519. System harmonic distortion study: Furnish a system harmonic distortion study as follows:

1. Obtain data on utility services, plant loads and plant operation. Verify electrical service rating including transformer size, short circuit capacity and X/R ratio.
2. Prepare a harmonic distortion study of plant electrical system to determine voltage and current harmonics at the point of common coupling for worst case speed and load settings.
3. Confirm that the submitted adjustable frequency drives limit the electrical disturbances below the 5 percent THD (voltage) and below the harmonic current distortion per Table 10.3 as established by IEEE 519.
4. Point of Common Coupling: The point of common coupling is defined as at the overcurrent device external of and directly upstream of the adjustable frequency drive assembly.
5. Include analysis of all data with recommendations.

G. Source quality-control reports.

H. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.5 QUALITY ASSURANCE

A. Failure to Meet the Harmonic Requirement as Determined by Field Measurement: If the installed adjustable frequency drives fail to meet the harmonic limits specified, modify the adjustable frequency drives as follows at no additional cost to the OWNER.

1. Provide additional harmonic reduction equipment until the specified limit is achieved. Equipment which requires expanding on the physical footprint of the adjustable frequency drive previously approved is to be submitted for approval.
2. In the event that harmonic distortion limits cannot be achieved, replace the adjustable frequency drive equipment with equipment that conforms to this specification.

1.6 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 Product options commonly available from manufacturers are included in square brackets throughout the Section Text. Not every manufacturer listed can provide every option offered; verify availability with manufacturers. For definitions of terms and requirements for Contractor's product selection, see Section 016000 "Product Requirements." Select manufacturer from the list below for your project.

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following for 6 pulse drive:

1. ABB, Electrification Business- ACH550 Series (Non-Bypass), ACS880 Series (Bypass w\Input Breaker).
2. Eaton.
3. Allen Bradley Rockwell Automation, Inc.
4. Schneider Electric USA, Inc.
5. Siemens Industry, Inc., Building Technologies Division (Rubican).

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
3. Provide adjustable frequency drives that fit the physical space shown. Units exceeding the dimensions shown will not be acceptable.
4. Provide adjustable frequency drives that automatically restart when power is restored after a power outage. Provide control logic so the drive is allowed to restart when power is restored.

B. Application: Constant torque and/or variable torque based on mechanical equipment application.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
4. Input Reactor: Provide input reactor or isolation transformer, if required, as determined by system harmonic distortion analysis.
5. Filter Sections: Provide dc link reactor and filter capacitors as required.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range for variable torque drive and 66 Hz, with torque constant as speed changes for constant-torque drive; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
1. Minimum Short-Circuit Current (Withstand) Rating: 65 kA for entire assembly. The rating shall exceed the available fault current at terminal.
2. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
3. Humidity Rating: Less than 95 percent (noncondensing).
4. Altitude Rating: Not exceeding 3300 feet.
5. Vibration Withstand: Comply with NEMA ICS 61800-2.
6. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
7. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.

8. Speed Regulation: Plus or minus 5 percent.
9. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
10. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: UL 489, molded-case switch, with power fuse block and current-limiting fuses or UL 489, thermal-magnetic circuit breaker or NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
4. NC/NO alarm contact (field adjustable) that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Provide adjustable frequency drives to meet the following requirements of IEEE 519:
1. Total harmonic distortion THD (Voltage): Maximum of five percent for general distribution systems as measured at the point of common coupling.
2. Total current harmonic distortion: Not to exceed the values in Table 10.3, Current Distortion Limits for General Distribution Systems (120 V through 69000 V) of IEEE-519 at the point of common coupling.
3. Capacitor traps for controlling harmonics that require tuning to the power system are not acceptable.

2.4 CONTROLS AND INDICATION

A. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

    a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

B. Historical Logging Information and Displays:
1. Running log of total power versus time.
2. Total run time.
3. Fault log, maintaining last four faults with time and date stamp for each.

C. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

D. Control Signal Interfaces:

1. Electric Input Signal Interface:

    a. A minimum of two programmable analog inputs: 0- to 10-V dc and/or 4- to 20-mA dc as per building automation.
    b. A minimum of six multifunction programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:

    a. 0- to 10-V dc.
    b. 4- to 20-mA dc.
    c. Potentiometer using up/down digital inputs.
    d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc and/or 4- to 20-mA dc), which can be configured for any of the following:

    a. Output frequency (Hz).
    b. Output current (load).
    c. DC-link voltage (V dc).

d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

E. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: Two.

A. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory. Communication bus shall include modbus RTU and TCP/IP; Ethernet for Ethernet/IP, coordinate exact requirement with building Integrator.

1. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations. Minimum of 5% line reactor.

B. EMI/RFI Filtering:

1. CE marked; certify compliance with IEC 61800-3 for Category C2.
2. Passive harmonic filter shall limit harmonic distortion to less than 5% Over a wide range under high background voltage distortion, true 65 kA SCCR, IEEE 519 latest addition compliance, increases drive uptime, eliminate nuisance tripping and generator compatible.

2.6 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode:
   1. Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.

C. Bypass Controller:

   1. Three-Contactor-Style Bypass: Three-contactor-style or two contactor with fuse-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

      a. Bypass Contactor: Load-break, NEMA-rated contactor.

D. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

   1. NORMAL/BYPASS selector switch.
   2. HAND/OFF/AUTO selector switch.
   3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
   4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

      a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
      b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

   5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

      a. CPT Spare Capacity: 50 VA.

      b. Solid-State Overload Relays:

         1) Switch or dial selectable for motor-running overload protection.
         2) Sensors in each phase.
         3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
         4) Analog communication module.

2.7 Retain first subparagraph below if alarm contacts on overload relays are ADDITIONAL FEATURES

A. Damper control circuit with end-of-travel feedback capability.

B. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

C. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

D. Remote digital operator kit.

E. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer.

2.8 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Other Wet or Damp Indoor Locations: Type 4X.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.9 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Unguarded.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.
4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 Type 4X Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

E. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R Type 4X Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Cooling Fan and Exhaust System: For NEMA 250, Type 1 and Type 12; UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

G. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Roof-Mounting Controllers on Cooling Tower Mezzanine: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."

D. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in each fusible-switch VFC.

G. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.

4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect,] Construction Manager, and Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Provide the services of a factory- trained service engineer, specifically trained on the adjustable: frequency equipment to assist in installation, start-up, testing, calibration, placing into operation and provide training
3. Test Reports: Furnish detailed test reports of all tests indicating test performed, discrepancies found, and corrective action taken.

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify [Architect], Construction Manager and Owner before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

SECTION 262933 - CONTROLLERS FOR FIRE PUMP DRIVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Full-service controllers.
2. Controllers for pressure-maintenance pumps.
3. Remote alarm panels.
4. Low-suction-shutdown panels.
5. Enclosures.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

A. ECM: Electronic control module.

B. MCCB: Molded-case circuit breaker.

C. PID: Proportional integral derivative.

1.3 SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of product indicated.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show tabulations of the following:

a. Each installed unit's type and details.

b. Enclosure types and details for types other than NEMA 250, Type 2.
c. Factory-installed devices.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of integrated unit.
f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.

4. Include diagrams for power, signal, alarm, control wiring, and pressure-sensing tubing.

C. Product Certificates: For each type of product indicated, from manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fire-pump controllers and associated equipment from single source or producer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 20.

B. IEEE Compliance: Fabricate and test enclosed controllers in accordance with IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory, and marked for intended location and application.

2.2 FULL-SERVICE CONTROLLERS

A. See DIV 23 for Fire Pump Controller Manufacturer List.

B. General Requirements for Full-Service Controllers:

1. Comply with NFPA 20
2. Combined automatic and nonautomatic operation.
3. Factory assembled, wired, and tested; continuous-duty rated.

C. Method of Starting:

1. Pressure-switch actuated.

    a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
    b. System pressure recorder, electric ac driven, with spring backup.
    c. Programmable minimum-run-time relay to prevent short cycling.
    d. Programmable timer for weekly tests.
2. Solid-State Controller: Soft Start, **Reduced-voltage** type.
3. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of electric or pressure actuators.

D. Method of Stopping: **nonautomatic shutdown after automatic starting**.

E. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.

F. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.

G. Door-Mounted Operator Interface and Controls:

1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:

    a. Microprocessor-based logic controller, with multiline digital readout.
    b. Membrane keypad.
    c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:

    a. Controller power on.
    b. Motor running condition.
    c. Loss-of-line power.
    d. Line-power phase reversal.
    e. Line-power single-phase condition.

4. Audible alarm, with silence push button.
5. Nonautomatic START and STOP push buttons or switches.

H. Optional Features:

1. Extra Output Contacts:

    a. One NO contact(s) for motor running condition.
    b. One set(s) of contacts for loss-of-line power.
    c. One each, Form C contacts for high and low reservoir level.

2. Local alarm bell.
3. Door-mounted thermal or impact printer for alarm and status logs.
4. Operator Interface Communications Ports: USB, TCP/IP Ethernet, and TIA-485.

I. ATS:

1. Complies with NFPA 20,.
2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
4. Allows manual transfer from one source to the other.
5. Alternate-Source Isolating and Disconnecting Means:
   a. Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker must be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.

6. Local and Remote Alarm and Status Indications:

   a. Normal source available.
   b. Alternate source available.
   c. In normal position.
   d. In alternate position.
   e. Isolating means open.

7. Audible alarm, with silence push button.
8. Nonautomatic (manual, nonelectric) means of transfer.
9. Engine test push button.
10. Start generator output contacts.
11. Timer for weekly generator tests.

2.3 CONTROLLERS FOR PRESSURE-MAINTENANCE PUMPS

A. See Div 23 for Manufacturers.

B. General Requirements for Pressure-Maintenance-Pump Controllers:

1. Type: UL 508, factory-assembled, -wired, and -tested, across-the-line controller; for combined automatic and manual operation.
2. Enclosure: UL 508 and NEMA 250, Type 2 for wall-mounting.
3. Factory assembled, wired, and tested.
4. Finish: Manufacturer's standard color paint.

C. Rate controller for scheduled horsepower and include the following:

1. Fusible disconnect switch.
2. Pressure switch.

3. Hand-off-auto selector switch.
4. Pilot light.
5. Running period timer.

2.4 REMOTE ALARM PANELS

A. General Requirements for Remote Alarm Panels: Factory assembled, wired, and tested; and complying with NFPA 20 .

B. Supervisory Control Voltage: 120 V(ac) single source.

C. Audible and Visual Alarm and Status Indications for Electric-Driven Pump Controllers:

1. Driver running.
2. Loss of phase.
3. Phase reversal.
4. Supervised power on.

5. Controller connected to alternate power source.

D. Audible alarm, with silence push button.

2.5 LOW-SUCTION-SHUTDOWN PANELS

A. See Div 23 for Manufacturers.

B. General Requirements for Low-Suction-Shutdown Panels:

1. Factory assembled, wired, and tested.
2. Prevents automatic start of fire pump, and shuts down automatically started fire pump, on low-suction pressure.
3. Manual reset.

C. Operation: Integral pressure switch.

D. Include audible and visual alarms and status indications, with silence push button, for the following conditions:

1. Control power available.
2. Low-suction pressure.
3. Normal-suction pressure.

2.6 ENCLOSURES

A. Fire-Pump Controllers, ATS, Remote Alarm Panels, and Low-Suction-Shutdown Panels: NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.

1. Indoor Locations Subject to Dripping Noncorrosive Liquids: Type 2 (IEC IP11).
2. Other Wet or Damp, Indoor Locations: Type 4 (IEC IP56).

B. Enclosure Color: Manufacturer's standard "fire-pump-controller red"

C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.

D. Optional Features:

1. Floor stands, 12 inch (305 mm) high, for floor-mounted controllers.
2. Space heater, **120 V(ac), with thermostat**.

2.7 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire-pump controllers in accordance with requirements in NFPA 20 and **UL 218**

1. Verification of Performance: Rate controllers in accordance with operation of functions and features specified.

B. Fire-pump controllers will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive equipment, with Installer present, for compliance with requirements and other conditions affecting performance.

B. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CONTROLLERS

A. Coordinate installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Install controllers within sight of their respective drivers.

D. Connect controllers to their dedicated pressure-sensing lines.

E. Wall-Mounting Controllers: Install controllers on walls with disconnect operating handles not higher than 79 inch (2 m) above finished floor, and bottom of enclosure not less than 12 inch (305 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

F. Floor-Mounting Controllers: Install controllers on concrete base(s), using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Comply with requirements for concrete bases specified in Section 260529 "Hangers and Supports for Electrical Systems."

1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.

G. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

H. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

I. Comply with NEMA ICS 15.

3.3 INSTALLATION OF REMOTE ALARM AND LOW-SUCTION-SHUTDOWN PANELS

A. Install panels on walls with tops not higher than **72 inch (1829 mm)** above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For ATS not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF POWER WIRING

A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 INSTALLATION OF CONTROL AND ALARM WIRING

A. Install wiring between controllers and remote devices and facility's central monitoring system. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."

B. Install wiring between remote alarm and low-suction-shutdown panels and controllers. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."

C. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Section 284621.11 "Addressable Fire-Alarm Systems."

D. Bundle, train, and support wiring in enclosures.

E. Connect remote manual and automatic activation devices where applicable.

3.6 IDENTIFICATION

A. Comply with requirements in NFPA 20 for marking fire-pump controllers.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Inspect and Test Each Component:

    a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
    b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
    c. Test continuity of each circuit.

2. Verify and Test Each Electric-Drive Controller:

    a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for motor, notify Construction Manager before starting the motor(s).
    b. Test each motor for proper phase rotation.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Representatives from manufacturers of fire-pump controllers must be present during acceptance tests and inspections in accordance with NFPA 20.

C. Acceptance tests and inspections must be witnessed by Construction Manager and authorities having jurisdiction.

D. Acceptance Tests and Inspections:

1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to Construction Manager and authorities having jurisdiction.
2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
3. Engage manufacturer's factory-authorized service representative to be present during the testing.
4. Perform field acceptance tests as outlined in NFPA 20.

E. Nonconforming Work:

1. Controllers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.

3.9 ADJUSTING

A. Adjust controllers and battery charger systems to function smoothly and as recommended by manufacturer.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.

C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

D. Set field-adjustable pressure switches.

3.10 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature in accordance with manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

END OF SECTION 262933

SECTION 263213.13 – DIESEL-ENGINE-DRIVEN GENERATOR SETS - PURCHASE

PART 1 - GENERAL

1.1 SUMMARY

A. Provide nine (9) Diesel Gensets for standby emergency power. The gensets shall be 13.2KV output and connected to the medium voltage paralleling metal-clad switchgear. The gensets shall be installed inside the Central Utility plant (CUP) on the second floor. The units will be connected to a multi-tank bulk fuel system. The radiator shall be engine mounted. Each unit will include an active filter diesel particulate reduction system. Each unit shall include a neutral grounding resistor. Include one roof mounted load bank matched to the generator unit size.

1. Appendix A: Spreadsheet identifies the known loads and establishes priorities for the generator loading.
2. 3MW units are used as the base minimum size for the document. A generator loading model must be created to show compliance per the specification. The model will determine the generator size used.
3. Alternate – Bid eight (8) 3.5MW units.

B. Section Includes:

1. Diesel engine.
2. Diesel fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Load bank.
7. Engine mounted radiator
8. Vibration isolation devices.
9. Finishes

C. Related Requirements:

1. Section 261327 "Medium Voltage, Paralleling Metal-Clad Switchgear" for controls and paralleling equipment for multiple parallel engine generators.
2. Section 261327.11 Sequence of Operation.

D. Drawings: EP-701, EP-704

1.2 DEFINITIONS

A. EPS: Emergency power supply.

B. ESS: Essential Supply System

C. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data on features, performance, electrical characteristics, ratings, and finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, SCADA interface devices, Ethernet interface, and display components.
2. Include rated capacities, operating characteristics, furnished specialties, factory settings, and accessories.
3. Bill of Materials
4. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
5. Diesel engine Manufacturer, Model, Piston displacement (cubic inches) and RPM.
6. Generator Manufacturer, Model, rated KVA and Rated KW.
7. Motor starting capability (sKVA) at 30% instantaneous voltage dip. Data provided based on 90% sustain voltage will not be accepted.
8. Include thermal damage curve for generator.
9. Include time-current characteristic curves for generator protective device.
10. Include fuel consumption in gallons per hour (liters per hour) at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
11. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
12. Include airflow requirements for cooling and combustion air in cubic feet per minute (cubic meters per minute) at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F (35, 27, 21, and 10 deg C). Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
13. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactance, and short-circuit current capability.

B. Shop Drawings:

1. Include a tabulation of installed devices with features and ratings.
2. Include plans and elevations for engine generator and other components specified. Indicate mounting side and access requirements for top-fed medium voltage terminal box.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4. Identify center of gravity, lifting points, lifting yoke/spreader assembly and locate and describe mounting and anchorage provisions.
5. Identify fluid drain ports and clearance requirements for proper fluid drain.
6. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
7. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
8. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.
9. Batteries and Battery Charger: Provide a battery system riser diagram. Provide power and control wiring diagrams and intertie connections, including to Paralleling Switchgear.
10. Control Panel: Provide schematics and intertie connections.
11. Remote annunciator information, dimensions, and wiring connections.
12. Include information and wiring connection schematics for Load Share Module and Voltage Regulator Controller to be in Paralleling Switchgear Master Controller.
13. Neutral Grounding Resistor: Provide plans, elevations, power and control wiring diagrams and intertie connections.
14. Load Bank: Provide plans, elevations, power and control wiring diagrams and intertie connections.
15. Silencer: Provide dimensional drawings with weight.
16. Active filter diesel particulate reduction system: Provide dimensions, weight, mounting and field assembly. Provide power and control wiring diagrams.
17. Provide spreadsheet table form list identifying all the metering and status points for generators and associated system devices. In table include columns for communication method and connection to Generator internal, Paralleling Switchgear Master Controller, SCADA and BMS.

C. Qualification Data: For manufacturer and testing agency.

D. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total dry and wet weights, including external silencer**,** active diesel particulate reduction system, neutral grounding resistor, skid-mounted load bank, and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to "Operation and Maintenance Data," include the following:

   a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
   b. Operating instructions laminated and mounted adjacent to generator location.
   c. Training plan.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: For each generator provide one set each of lubricating oil, fuel, and combustion-air filters.
2. Provide a lockable cabinet sized for storage of the filters, manuals and miscellaneous material for the gensets.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
B. Source Testing Qualifications: Manufacturers standard testing procedures and ISO requirements.
C. Field Testing Qualifications: Factory Certified Technicians

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace 100% of components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period. Warranty shall include all parts, materials, labor and travel expenses necessary for repairs at the job site.

1. Warranty Period: Seven (7) years from date of startup commissioning.

1.8 MAINTENANCE SERVICE

A. The engine generator supplier shall maintain 24-hour parts and service capability within 25 miles of the project site. The distributor shall stock parts as needed to support the generator set package for this project site. The distributor shall carry enough inventory to cover no less than 80% of the parts service within 24-hours and 95% within 48-hours.
B. Starting on date of startup commissioning, provide seven (7) years full maintenance by certified employees of manufacturer’s designated service organization. Include semi-annual preventive maintenance and exercising to check for proper starting, load transfer and running under load. Include routine preventative maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
C. Provide field reports and document modifications on record drawings and in O & M manuals.

1.9 START-UP AND FINAL SYSTEM COMMISSIONING

A. Installation and Startup: Provide manufacturer certified field service technician(s) required for a complete installation. To include field programming adjustments, start up, field quality control and commissioning of equipment. (Estimated October 2024).

B. Final System Commissioning: Provide manufacturer certified field service technician(s) required for a Final System Commissioning. To include field programming adjustments, field quality control and commissioning of equipment. (Estimated October 2026).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Caterpillar, Inc
B. Cummins Power Generation
C. Kohler Power Systems

D. MTU Onsite Energy Corporation
E. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, day tank, engine generator, batteries, battery racks, silencers, grounding resister, load bank, active filter diesel particulate reduction system equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: 1.5.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 EPSS.

D. Engine Exhaust Emissions: Comply with EPA Tier 2 requirements and applicable state and local government requirements. Provide an active filter diesel particulate reduction system in addition to the Tier 2 requirements.

E. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 41 to 104 deg F (5 to 40 deg C).
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

2.3 SEQUENCE OF OPERATION

A. See Section 261327.11 “Sequence of Operation”.

B. Generator set shall start on receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set control and a redundant signal over the required network connection.

C. The generator set shall complete a time delay start period as programmed into the control.

D. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:

1. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set and indicate “fail to crank” shutdown.
2. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate “fail to start”.
3. The engine shall accelerate to rated speed and the alternator to rated voltage.
4. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous state.
5. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
6. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.
7. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

2.4 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Power Rating: Standby.

D. EPSS Class: Engine generator shall be classified as a Class 96 according to NFPA 110.

E. Service Load: 3750 kVA basis of minimum design. System model shall determine unit size.

F. Power Factor: 0.8, lagging.

G. Frequency: 60 Hz.

H. Voltage: 13,200V ac.

I. Phase: Three-phase, four wire, wye. Neutral to be bonded to ground at generator.

J. Induction Method: Turbocharged.

K. Governor: Adjustable isochronous, with speed sensing and interface with load share modules and paralleling master controller in switchgear. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. The engine governor shall be an electronic Engine Control Module (ECM) with 24V DC Electric Actuator. The ECM shall be enclosed in an environmentally sealed, die-cast aluminum housing which isolates and protects electronic components from moisture and dirt contamination. The ECM shall adjust fuel delivery per exhaust smoke, altitude and cold mode limits. In the event of a DC power loss, the forward acting actuator will move to the minimum fuel position.

L. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

M. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

N. Engine Generator Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Deviation: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Deviation:

a. 100% BMEP increase: Less than or equal to a 15 percent voltage decrease.
b. 100% load decrease: Less than or equal to a 20 percent voltage increase.
c. Voltage shall recover and remain within the steady-state deviation within four (4) seconds.

4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.5 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Deviation from rated frequency:

a. 100% BMEP increase: Less than or equal to a 7 percent frequency decrease.
b. 100% load decrease: Less than or equal to a 10 percent frequency increase.
c. Frequency shall recover and remain within the steady-state operating band within three (3) seconds.

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: Shall meet NFPA 110, Type 10 system requirements.

O. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.

2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.5 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Size: 16 cylinders, minimum 75 Liter with maximum BMEP of 410PSI.

D. Lubrication System: Engine or skid-mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
4. Lube oil pump and oil level regulator.

E. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499 and with NFPA 110 requirements for Level 1 equipment for heater capacity. Provide isolation valves that allow for change out of the heater without having to drain the system.

1. The coolant heater shall be provided with a DC thermostat, installed at the engine thermostat housing.
2. An AC power connection box shall be provided for a single AC power connection to the coolant heater system. The heater voltage will be 480V.

F. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Integral fuel oil cooler shall be provided as required by the OEM.
6. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 215 deg F (102 deg C), and noncollapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

G. Muffler/Silencer: Hospital / Super Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Include valved condensate drain, extended beyond insulation depth.
3. Maximum 12 inch water column drop.
4. Include stainless steel flex connectors, flanges and fittings for a complete system.

H. Active Diesel Particulate Filter: Provide a complete system.

1. Rypos Brand ADPF-9 is the basis of design. Contact Bill Collins, (508) 429-4552, bcollins@rypos.com . Equivalent systems must be submitted for pre-approval.
2. ADPF shall be sized based on the engine data provided to achieve at least the levels equivalent to, CARB verification to level III+ for emissions reduction.
3. DPF shall incorporate Active regeneration in that it burns off the soot particles without a minimum exhaust temperature or engine minimum load or runtime requirements. It shall regenerate at low engine loads including under idling conditions.
4. ADPF shall be a minimum of 80% porous, and shall regenerate when energized electrically, independent of exhaust temperatures.
5. ADPF shall include differential pressure sensors to initiate and control regeneration process as a function of backpressure. Backpressure must not exceed 90% of the engine manufacturer’s specification.
6. ADPF shall receive power from an emergency power source.
7. ADPF shall meet the following minimum requirements:
    a. PM Reduction: 85%
    b. Hydrocarbon reduction: 75%
    c. Carbon Monoxide reduction: 70%
    d. Nitrogen Dioxide reduction (NO2): 40%
8. ADPF shall
    a. be suitable for horizontal mounting, with flanged inlets and outlets.
    b. be coupled to engine exhaust outlets by means of an adequately sized section of corrugated flex. Flex connectors shall be flanged at both ends for mating to the engine and exhaust system.

9. ADPF shall give visual notification and connect to SCADA system for monitoring:
   a. Operating normally.
   b. Backpressure exceeds normal operating conditions.
10. ADPF shall be able to operate effectively within the engine manufacturer's recommended operating profile, while operating within the acceptable backpressure range as specified by engine manufacturer; without limiting variation in engine loading levels and/or number of cold starts beyond specification by the engine manufacturer.

I. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level Type 1.
4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
   a. Sizing shall include capacity of connection with Paralleling Switchgear during generator startup.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide battery gases monitoring controller with alarm contacts.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 45-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
   a. Operation: Equalizing-charging rate of 20 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a

lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F (minus 40 to plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.6 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 37.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel. Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron. Provide water separator and fuel filters. Fuel filters shall have isolation valve for changing of filter during engine operation.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Fuel-Oil Storage Tank: **This section included for connection reference only – items not included in this equipment purchase scope.**

1. Fuel Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills plus fuel for the hours of continuous operation required for the indicated EPSS Class 96.
2. Duplex Fuel-Oil Transfer Pump.
3. Fuel Polishing System to include filtering and pumps.

G. Day Tank: **This section included for connection reference only – items not included in this equipment purchase scope.**

1. Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump.
2. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.

    a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

3. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine generator system without being refilled.
4. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
5. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
6. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
7. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
8. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor-control device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine generator.

2.7 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in main or redundant paralleling master controller initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

C. Comply with UL 508A.

D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel

mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

E. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, for each phase.
    f. AC ammeter, for each phase.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low-water temperature alarm.
    g. High engine temperature prealarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.
    l. Low fuel day tank.

        1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required for the indicated EPSS class.

    m. Coolant low-level alarm.
    n. EPS load indicator.
    o. Battery high-voltage alarm.
    p. Low cranking voltage alarm.
    q. Battery-charger malfunction alarm.
    r. Battery low-voltage alarm.
    s. Contacts for local and remote common alarm.
    t. Remote manual stop shutdown device.

u. Hours of operation.
v. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

F. Connection to Gateway:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for Gateway transmission of indications to remote data terminals via Ethernet.

G. Inputs and Outputs

1. Programmable Digital Inputs. The Controller shall include the ability to accept programmable digital input signals. The signals may be programmed for either high or low activation using programmable Normally Open or Normally Closed contacts.
2. Programmable Relay Outputs. The control shall include the ability to operate programmable relay output signals, integral to the controller. The output relays shall be rated for 2A @ 30VDC and consist of six (6) Form A (Normally Open) contacts and two (2) Form C (Normally Open & Normally Closed) contacts.
3. Programmable Discrete Outputs. The control shall include the ability to operate two (2) discrete outputs, integral to the controller, which are capable of sinking up to 300mA per input.
4. Integrated PLC Functionality. The panel shall allow the operator to create custom logic functions to provide additional user defined control of the generator set operation.

H. Accessibility and Maintenance

1. All engine, voltage regulator, control panel and accessory units shall be accessible through a single electronic service tool. The following maintenance functionality shall be integral to the generator set control:

a. Engine running hours display
b. Service maintenance interval (running hours or calendar days)
c. Engine crank attempt counter
d. Engine successful starts counter
e. 40 events are stored in control panel memory
f. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 7 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:

1) Day of week
2) Time of day to start
3) Duration of cycle

I. Remote Communications

1. Remote Communications. The control shall include Modbus TCP communications as standard via Ethernet.
2. Coordinate connection to main and redundant paralleling master controller located in the “Medium-Voltage Paralleling Metal Clad Switchgear”, section 261327. Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

J. Local and Remote Annunciation

1. Local Annunciator (NFPA 99/110, CSA 282). Provide a local, control panel mounted, annunciator to meet the requirements of NFPA 110, Level 1.

   a. Annunciator shall be networked directly to the generator set control.
   b. Local Annunciator shall include a lamp test pushbutton, alarm horn and alarm acknowledge pushbutton.

2. Remote Annunciator. Provide a remote annunciator to meet the requirements of NFPA 110, Level 1. Coordinate with Paralleling Master Controller.

   a. The annunciator shall provide remote annunciation of all required points and shall incorporate ring-back capability so that after silencing the initial alarm, any subsequent alarms will sound the horn. Ability to be located up to 4000 ft from the generator set without the use of a data repeater.

K. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

L. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.8 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the

generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.

D. Generator circuit breaker and protective relay shall be in the medium voltage paralleling metal clad switchgear. Protective relaying will require CT’s and PT’s be installed on the generator. Interconnecting wiring points shall be coordinated. Refer to section 261327 medium voltage paralleling metal clad switchgear.

2.9 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.
B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
C. Electrical Insulation: Class H.
D. Alternator Pitch: 2/3.
E. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six-lead alternator.
F. Range: Provide limited range of output voltage by adjusting the excitation level.
G. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
H. Enclosure: Drip proof.
I. Instrument Transformers: Mounted within generator enclosure.
J. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 25 percent on one step, 100 percent full load.
3. Provide anti-hunt provision to stabilize voltage.

4. Maintain frequency within 2 HZ, 50 percent full load and stabilize at rated frequency within 3 seconds.

K. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

L. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

M. Subtransient Reactance: 12 percent, maximum.

2.10 NEUTRAL GROUNDING RESISTOR

A. Neutral Grounding Resistor: Provide with unit and sized per manufacturer recommendation.

2.11 LOAD BANK

A. Description:

1. Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, resistive unit capable of providing a balanced three-phase, delta-connected load to engine generator at 100 percent rated-system capacity, at 80 percent power factor, lagging. Unit shall include a control panel capable of selective control of load. The four configurable step changes available shall be 500KVA, 500KVA, 1000KVA and 1000KVA.

B. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and stainless-steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases. Galvanized steel is prohibited. Element's maximum resistance shall be between 100 and 105 percent of rated resistance.

C. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.

D. Load-Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.

E. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.

F. Load-Bank Enclosures: NEMA 250, Type 3R, aluminized steel complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- (13-mm-) square, galvanized-steel mesh. Components other than resistive elements shall receive exterior epoxy coating with compatible primer.

G. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.

H. Load-Bank Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.

I. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

2.12 VIBRATION ISOLATION DEVICES

A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch (25 mm).

B. Provide flexible connector for vibration isolation connection to steel piping.

C. Provide flexible connector for vibration isolation connection to exhaust shroud and ductwork.

D. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

E. Provide additional isolations devices as required for seismic requirements.

2.13 FINISHES

A. Indoor Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.14 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components, and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115 and with NFPA 110, Level 1 Energy Converters.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MAINTENANCE SERVICE

A. See Part 1 – 1.9 Maintenance Service. This contract shall be executed directly with the Owner.

3.3 FIELD QUALITY CONTROL

A. Provide factory certified technician(s) to perform tests, inspections, equipment adjustments, startup and commissioning. See above, Part 1 - 1.8 Warranty and Part 1 – 1.10 Start-Up.

3.4 SYSTEM FUNCTION COMMISSIONING TESTS

A. Manufacturer's Field Service: Provide factory-authorized service technician(s) to provide startup and commissioning of each generator.

1. Services to include service technician(s) being on site as each generator is energized to test programing and functionality.
2. Provide documentation confirming results of testing.
3. Provide field programming adjustments required to complete field quality control, startup and commissioning.

B. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Generator functional tests timing shall be coordinated with the functional testing of the medium voltage paralleling metal clad switchgear
2. Develop test parameters and submit to Owner/Project Representative minimum of eight (8) weeks prior to testing for review and approval.
3. Perform approved submittal tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
4. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
5. Verify the correct operation of sensing devices, alarms, and indicating devices.
6. Complete system function tests for each mode in Section 261327.11 “Sequence of Operation”.

    a. Including a full power loss test.
    b. Tests to model the loss of generator units during loss of power event.
    c. Tests to model generator units not starting when called to service and loss of generator during service.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.13

SECTION 263213.13.1 – DIESEL-ENGINE-DRIVEN GENERATOR SETS - INSTALL

PART 1 - GENERAL

1.1 SUMMARY

A. Install nine (9) Diesel Gensets for standby emergency power. The gensets shall be 13.2KV output and connected to the medium voltage paralleling metal-clad switchgear. The gensets shall be installed inside the Central Utility plant (CUP) on the second floor. The units will be connected to a multi-tank bulk fuel system. The radiator shall be engine mounted. Each unit shall include a neutral grounding resistor. Include one roof mounted load bank matched to the generator unit size.

1. Appendix A: Spreadsheet identifies the known loads and establishes priorities for the generator loading.

B. Related Requirements:

1. 263213.13 Diesel Engine-Driven Generator Sets – Purchase.
2. 261327 Medium-Voltage Paralleling Metal-Clad Switchgear – Purchase.
3. 261327.1 Medium-Voltage Paralleling Metal-Clad Switchgear – Install.
4. 261327.11 Sequence of Operation.

1.2 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. Operational Bandwidth: The total variation, from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.3 SUBMITTALS

A. Include plans and elevations for engine generator and other components specified. Indicate mounting side and access requirements for top-fed medium voltage terminal box.

B. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Neutral Grounding Resistor: Provide plans, elevations, power and control wiring diagrams and intertie connections.

D. Load Bank: Provide plans, elevations, power and control wiring diagrams and intertie connections.

E. Qualification Data: For installer and testing agency.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For engine generators to include in emergency, operation, and maintenance manuals.

B. Provide a cabinet for the storage of extra maintenance materials, tools and documents.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Field Testing Qualifications: Factory Certified Technicians

1.6 WARRANTY

A. Installer Warranty: Installer agrees to repair or replace 100% of components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period. Warranty shall include all parts, materials, labor and travel expenses necessary for repairs at the job site.

1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS – (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases.
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with restrained spring isolators and seismic restraints. Secure to anchor bolts installed in concrete bases.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) of clearance from combustibles.

F. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 232116 "Hydronic Piping Specialties."

G. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
2. Copper and galvanized steel shall not be used in the fuel-oil piping system.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Additional requirements for diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect low voltage wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

G. Connect medium voltage wiring according to Section 260513 Medium Voltage Cables.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will engage a qualified testing agency and or manufacturer factory certified representative to perform tests and inspections. Coordinate testing with Manufacturer to ensure a full factory warranty.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in the NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with Drawings and the Specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests according to IEEE 43.

a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Conduct performance test according to NFPA 110.
6) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.

a. Coordinate with Utility for 100% power loss test. Full test with priority load pick up and test for load shed in the event of genset failure.
b. provide a rental genset connected to system to test for paralleling control.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold.

Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

C. Coordinate tests with tests with the medium voltage paralleling metal clad switchgear.

D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component, indicating satisfactory completion of tests.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels, so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

A. Provide a factory field service engineer to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Plan for a full eight hour day on-site with information and hands-on equipment training and operation. On-site time for demonstration is separate from startup, field quality control and commissioning time.

END OF SECTION 263213.13.1

SECTION 263323.11 - CENTRAL BATTERY EQUIPMENT FOR EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Uninterruptible (UPS-type) central battery equipment.
2. Enclosures.
3. Optional and accessory features.

B. Related Requirements:

1. Section 263353 "Static Uninterruptible Power Supply" for power conversion equipment (UPS), with central batteries, not used for emergency lighting.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. IBC: International Building Code.

C. LED: Light-emitting diode.

D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

E. OCPD: Overcurrent protective device.

F. PC: Personal computer.

G. PWM: Pulse-width modulated.

H. TDD: Total demand (harmonic current) distortion (also listed as "THD" in catalog data by manufacturers).

I. THD(V): Total harmonic voltage demand.

J. Uninterruptible: As used in the Section Text, an on-line, double-conversion (rectifier/inverter) unit, with no interruption of power to the load on interruption and restoration of the "normal" source.

K. UPS: Uninterruptible power supply.

L. VRLA: Valve-regulated lead acid.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of central battery equipment unit.

1. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, shipping splits, and furnished options, specialties, and accessories.

B. Shop Drawings: For each type and rating of central battery equipment unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, ventilation requirements, method of field assembly, components, and location and size of each field connection.
3. Include system one-line diagram, internal and interconnecting wiring; and diagrams for power, signal, and control wiring.
4. Include elevation, details, and legends of control and indication displays.
5. Include -circuit current (withstand) rating of unit.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around central battery equipment. Show central battery equipment layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For Installer and testing agency.

C. Seismic Qualification Data: For central battery equipment, accessories, and components, from manufacturer.

1. Certificate of compliance.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of central battery equipment.

E. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for input filtering of central battery equipment to limit TDD and THD(V) to specified levels.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For central battery equipment to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing central battery equipment.
b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
c. Manufacturer's written instructions for selecting and setting field-adjustable controls and status and alarm points

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.

1. Fuses: One for every 10 of each type and rating, but no fewer than Three (3) of each type.
2. Output Circuit Breakers: One for every 10 of each type and rating, but no fewer than One (1) of each type.
3. Output Circuit Breaker Open/Tripped Alarm Contacts: One for every 10 supplied, but no fewer than One (1) of each type.
4. Cabinet Ventilation Filters: One complete set.
5. Circuit Board: One spare circuit board for each critical circuit.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Testing Agency Qualifications: Member company of NETA or an NRTL acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles.

B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
2. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
3. Humidity: More than 95 percent (condensing).
4. Altitude: Exceeding 3300 feet (1000 m).

B. Interruption of Existing Electrical Distribution Systems: Do not interrupt electrical distribution systems within facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary electrical service.
3. Do not proceed with interruption of electrical systems without Construction Manager's written permission.
4. Comply with NFPA 70E.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for central battery equipment, including clearances between central battery equipment and adjacent surfaces and other items.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace central battery equipment that fails in materials or workmanship within specified warranty period. Special

warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:

    a. Central Battery Equipment (excluding Batteries): Two year(s).
    b. Standard VRLA Batteries:

        1) Full Warranty: One year(s).
        2) Pro Rata: Nine years.

    c. Premium VRLA Batteries:

        1) Full Warranty: One year(s).
        2) Pro Rata: Nineteen years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Central battery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated central battery equipment shall be tested and certified by an NRTL as meeting ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 UNINTERRUPTIBLE (UPS-TYPE) CENTRAL BATTERY EQUIPMENT

A. Uninterruptible (UPS_TYPE) Central Battery Equipment shall be supplied by one of the following manufactures:

1. DUAL LITE – TRIDENT SERIES
2. EMERGI – LITE
3. EATON
4. MITSUBISHI ELECTRIC

B. General Requirements for Central Battery Equipment:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Comply with NEMA PE 1.

C. Performance Requirements for UPS-Type Central Battery Equipment:

1. Type: On-line, double conversion.
2. Continuously provide uninterrupted ac power to connected emergency electrical lighting system.
3. Automatic Operation:

    a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier and inverter, with battery connected in parallel with rectifier output.
    b. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
    c. If normal power fails, battery continues to supply regulated ac power through the inverter to the load without switching or disturbance.
    d. When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier then supplies power to the load through the inverter and simultaneously recharges battery.
    e. If battery becomes discharged and normal supply is available, rectifier charges battery. When battery is fully charged, rectifier automatically shifts to float-charge mode.
    f. If any element in the rectifier/inverter string fails and power is available at normal supply terminals of system, static transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
    g. If a fault occurs in system supplied by the inverter output, and current flows in excess of the overload rating of the inverter, static transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
    h. When fault has cleared, static transfer switch returns the load to inverter output.
    i. If battery is disconnected, inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

4. Manual Operation:

    a. Turning inverter off causes static transfer switch to transfer the load directly to normal ac supply circuit without disturbance or interruption.

b. Turning inverter on causes static transfer switch to transfer the load to inverter.

5. Maximum Acoustical Noise: 75 dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 39 inches from nearest surface of component enclosure.

D. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 20 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: Plus or minus 5 percent of central battery equipment frequency rating.
3. Synchronizing Slew Rate: 10 Hz per second, maximum.
4. Minimum Off-Line Efficiency: 95 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F (20 deg C) and not exceeding 86 deg F (30 deg C).
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F (70 deg C).
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C).
10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet (1005 m).
12. Off-Line Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

E. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

F. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

a. Normal power available.
b. Status of system.
c. Battery charging status.
d. On battery power.
e. System fault.
f. External fault.

2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

    a. Keypad: In addition to required programming and control keys, include the following:

        1) Keys for METER, CONTROL, PROGRAM, and CLEAR modes.
        2) Security Access: Provide electronic security access to controls through identification and password with at least two levels of access: View only; and view, operate, and service.
        3) Control Authority: Supports at least three conditions: Off, local manual control at unit and local automatic control at unit.

    b. Digital Display: Plain-English language messages on a digital display; provide the following historical logging information and displays:

        1) Real-time clock with current time and date.
        2) Tests and Events Logs: Record and store up to 25 tests and events:

            a) Dates.
            b) Times.
            c) Durations.
            d) Output voltage and currents.

        3) Alarm Logs: Record and store up to 25 alarms:

            a) Dates.
            b) Times.
            c) Alarm type.

        4) Metering Functions: Display central battery equipment metering parameters including, but not limited to, the following:

            a) Input and output voltage (V ac) and output current (A ac).
            b) Battery voltage (V dc) and current (A ac).
            c) Fault or alarming status (code).
            d) Power output (VA).
            e) Inverter load (W).
            f) Ambient temperature (deg F).
            g) System run time (cumulative days).
            h) Inverter run time (cumulative minutes).

5) Alarm Functions: Digital display mounted flush in unit door and connected to display central battery equipment parameters including, but not limited to, the following:

a) High/low battery charge voltage.
b) High/low input voltage.
c) Battery nearing low-voltage condition.
d) Battery low voltage.
e) High ambient temperature.
f) Inverter fault.
g) Output fault.
h) Output overload.

3. Remote Signal Interfaces:

a. Remote Indication Interface: A minimum of one programmable (Form C) dry-circuit relay output(s) (120-V ac, 2 A) for remote indication of the following:

1) Fault or status indication.
2) On bypass.
3) Low battery.

b. Communications Interface: Factory-installed hardware and software to enable a remote PC to monitor and display status and alarms.

1) Communications Ports : RS-232**.**
2) Network Communications Ports: Ethernet.
3) Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

H. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: 65 kA.

I. Rectifier:

1. Description: Solid state, with the following operational features:

a. Automatically convert incoming ac voltage to regulated dc bus voltage, with less than 2 percent rms ripple voltage with inverter fully loaded and batteries disconnected.
b. Rectified Efficiency: Not less than 97 percent.
c. Generator compatible.

J. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

a. Automatically regulate output voltage to within plus or minus 5 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes, with recovery within 3 cycles.
b. Automatically regulate output frequency to within plus or minus 0.5 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
c. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.
d. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.
e. Load Power Factor: 0.5 lead to 0.5 lag.

K. Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

L. Batteries:

1. Description: Standard VRLA batteries.

a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

M. Line Conditioning and Filtering:

1. Input Line Conditioning:

    a. Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD at input terminals of all central battery equipment to less than 10] percent and THD(V) to 5 percent.
    b. Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD and THD(V) at the defined point of common coupling per IEEE 519.

2. Output Voltage Waveform:

    a. Sine wave with maximum 3 percent TDD throughout battery operating-voltage range, for 100 percent linear load.

N. Maintenance Bypass Systems:

1. Maintenance Bypass Mode:

    a. Internal; manual operation only; bypasses central battery equipment power circuits (inverter and static transfer switch); requires local operator selection at central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
    b. External; manual operation only; bypasses central battery equipment completely; requires local operator selection at external switch enclosure remote from central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.

2. Bypass Overload Capability: 1.5 times the base load current.

O. Integral Output Disconnecting Means and OCPD:

1. Single-Output OCPD: Thermal-magnetic circuit breaker, complying with UL 489; manufacturer's standard ratings based on unit output ratings.
2. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.

    a. Normally Closed: 2.
    b. Normally Open: 2.

2.3 ENCLOSURES

A. Central Battery Equipment Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

2.4 OPTIONAL AND ACCESSORY FEATURES

A. Factory-Installed Options and Accessories:

1. Multiple-Output Voltages: Supply unit branch circuits at different voltage levels if required. Transform voltages internally as required to produce indicated output voltages.
2. Split-Output Configuration: Divides output into normally on and normally off buses.
3. Auto-dialer.
4. Internal fax modem.
5. Audible alarm with silencer switch.
6. Remote Summary Alarm Panel: Labeled LEDs on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions; silencing switch in face of panel silences signal without altering visual indication.

    a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
    b. Maximum Distance from Main Unit: 1000 feet (304 m).

7. Remote Meter Panel: Match equipment requirements of remote monitoring, controlling, and programming of central battery equipment.

    a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
    b. Maximum Distance from Main Unit: 150 feet (46 m).

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate central battery equipment fabricator's quality-control and testing methods.

B. Testing: Test and inspect central battery equipment according to UL 924.

C. Factory Tests: Test and inspect assembled central battery equipment, by a qualified testing agency, according to UL 924. Affix standards organization's label. Include the following:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.

4. Overload test.
5. Power failure test.

D. Central battery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store central battery equipment according to NECA 411.

B. Examine areas, surfaces, and substrates to receive central battery equipment, with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.

C. Examine equipment before installation. Reject equipment that is wet, moisture damaged, or mold damaged.

D. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HARMONIC ANALYSIS STUDY

A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for central battery equipment input filtering to limit TDD and THD(V) to specified levels.

B. Prepare a harmonic analysis study and report complying with IEEE 399 and with NETA Acceptance Testing Specification.

3.3 INSTALLATION, GENERAL

A. Coordinate layout and installation of central battery equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required

workspace clearances and required clearances for equipment access doors and panels.

B. Install central battery equipment and accessories according to NECA 411.

C. Wall-Mounted Central Battery Equipment: Install central battery equipment on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For units not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

D. Suspended-Mounted Central Battery Equipment: Suspend central battery equipment from structural ceiling components using hangers, clamps, and associated fittings, designed for types and sizes of units to be supported. Provide support devices complying with Section 260529 "Hangers and Supports for Electrical Systems."

E. Floor-Mounted Central Battery Equipment: Install central battery equipment on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

F. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

H. Comply with NECA 1.

I. Wiring Methods:

1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters.
2. Install cables in raceways and cable trays except within consoles, cabinets, desks, counters, accessible ceiling spaces, and gypsum board partitions where unenclosed wiring method may be used.
3. Install conductors and cables concealed in accessible ceilings, walls, and floors where possible.
4. Conceal raceway and cables except in unfinished spaces.

5. Provide plenum-rated cable, where installed exposed or in open cable tray, within environmental airspaces, including plenum ceilings.
6. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
7. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

J. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.4 CONNECTIONS

A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 INSTALLATION OF CONTROL WIRING

A. Install wiring between central battery equipment and remote devices. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

3.6 IDENTIFICATION

A. Identify central battery equipment, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label central battery equipment with engraved nameplates.
3. Label each separate cabinet, for multicabinet units.
4. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for central battery equipment, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of central battery equipment units.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Acceptance Testing Preparation:

1. Inspect and Test Each Component:

    a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
    b. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
    c. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect central battery equipment, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
2. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
3. Test continuity of each circuit.
4. Verify that input voltages and frequencies at central battery equipment locations are within voltage and frequency limits specified in Part 2. If outside this range, notify Construction Manager before closing input OCPDs.
5. Perform each visual and mechanical inspection and electrical test stated in manufacturer's written instructions and in NETA Acceptance Testing Specification, including specifically those for batteries, battery chargers, and UPS, regardless of the type of central battery equipment provided. Certify compliance with test parameters.
6. Perform a load-duration test at rated voltage and rated output current to verify the correct functional operation of the unit under full-load stable operating conditions for the minimum time limits required by UL 924. Monitor and record ambient temperature and temperatures within the unit.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of central battery equipment. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of central battery equipment 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Central battery equipment will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies central battery equipment and describes all test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.9 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, and other adjustable parts.

C. Adjust the trip settings of thermal-magnetic circuit breakers with adjustable, instantaneous-trip elements; install fuses if not factory installed.

D. Set the automatic system test parameters.

E. Set field-adjustable, circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.10 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace central battery equipment whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain central battery equipment, and to use and reprogram microprocessor-based control, monitoring, and display functions.

END OF SECTION 263323.11

SECTION 263343 - BATTERY CHARGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data: For each type of battery charger.

1. Include system overview, construction details, material descriptions, and dimensions of battery charging and monitoring systems.
2. Include rated capacities, operating characteristics, electrical characteristics, performance specifications, and furnished accessories.

B. Shop Drawings: For battery chargers.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field installation, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include instructions for Installer.

C. Qualification Data: For manufacturer.

D. Seismic Qualification Data: Certificates, for battery changers**,** accessories, and components, from manufacturer.

1. Basis for Certification: Include Certificate of Compliance for nonstructural components and systems. Withstand certification is for below-grade, grade, and roof-level installations, installations in essential facilities, and for life-safety

applications, based on actual shake-testing. Certified installation locations shall include mounting directly to structural wall and directly to nonstructural wall.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For battery chargers to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's operating specifications and user's guides.
b. Data sheet for each battery charger with nameplate information and performance specifications.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide certification that manufacturer complies with requirements of ISO 9001.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of battery chargers that fail in materials or workmanship within specified warranty period.

1. Warranty Period 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 1236 for Category BBHH. OEM-supplied, open-frame chargers may be UL recognized to Category BBHH provided they are housed in a listed enclosure.

C. NFPA Compliance: Comply with NFPA 110.

D. Environmental Conditions: Battery charger shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 40 to plus 158 deg F with full charger output available up to 104 deg F.
2. Relative Humidity: 5 to 95 percent.
3. Altitude: Meets full performance from sea level to 5000 feet. Chargers installed at higher altitudes may automatically derate output power to prevent overheating of internal components, but shall remain operable.
4. Electromagnetic Immunity: Charger power terminals shall be immune to conducted and radiated electromagnetic energy to IEC 61000-4-12.
5. Vibration Resistance: Charger enclosure rated to IEC 60068-2-6 vibration test; 4-g force from 18 to 500 Hz on 3 axes; and 0.01 power spectral density value from 20 to 500 Hz.

E. Seismic Performance: Provide supporting per 260011 “Facility Performance Requirements for Electrical” and 260548.16 “Seismic Controls for Electrical Systems.”

F. Battery-Charger Power Conversion Energy Efficiency:

1. Certified to California Code of Regulations, Title 20, "Appliance Efficiency Regulations";
https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.
2. Comply with Oregon Department of Energy standards for appliance energy efficiency.

2.2 BATTERY CHARGERS FOR EMERGENCY ENGINE GENERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cummins Power Generation.
2. GE Power; General Electric Company.
3. Stored Energy Systems LLC.

B. Source Limitations: Obtain battery chargers from single source from single manufacturer.

C. Battery-Charger Operation: Current-limited, constant-voltage, automatic-boost type charger designed for nickel-cadmium batteries, with the following features:

1. Automatic Boost Mode: Operates in boost charging mode after battery discharge. Boost duration automatically adjusted depending on the following:

a. Differing depths of battery discharge.
b. Differing relationships of battery amp-hour capacity to charger ampere output.
c. Differing parasitic direct current loads.

2. Output Voltage Regulation: Charger regulates output to within plus or minus 0.5 percent of manufacturer-provided voltage settings despite variations of input voltage, input frequency, and output current.

3. Battery Thermal Compensation: Battery temperature compensation with adjustable slope, factory set at minus 0.18 percent per degree C, and equipped for sensing battery temperature. Include battery temperature sensor mounted on battery negative terminal.
4. Automatic Dead Battery Recharge: Charger automatically recharges a battery discharged to 0 V at full-rated output current, without the need for user intervention.
5. AC Input: Charger operates from any 47- to 63-Hz ac source with voltage ranging from 90- to 265-V rms.
6. Charger Enclosure: NEMA 250, Type 1 (IP20), wall mounted and rated for generator duty with charger enclosure vibration resistance. Housing materials: aluminum or stainless steel.

D. Battery-Charger Status Indication and Alarms:

1. Output Voltage and Current: Digital or analog meters on front panel, or by conveying performance data to generator control panel via J-1939 datalink. Accuracy: Plus 2 percent for voltage and plus 5 percent for current.
2. Alarm Outputs: Individual Form C contacts, or by conveying alarms to generator control panel via J-1939 datalink.

a. AC voltage failure.
b. Low dc voltage.
c. High dc voltage.
d. Low cranking voltage.

2.3 SOURCE QUALITY CONTROL

A. Testing: Test and inspect battery chargers according to UL 1236 for Category BBHH recharge performance.

B. Battery charger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, mounting locations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting battery-charger performance.

B. Examine roughing-in for conduit systems and electrical connections to verify actual locations of connections before battery-charger installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BATTERY-CHARGER INSTALLATION

A. Follow manufacturer's written instructions to prevent damage from static electricity. Provide clearances for service and ventilation.

B. Battery chargers are configured at the factory. If settings need to be field-configured, follow manufacturer's setup written instructions.

C. Coordinate jumper datalinks with emergency generator control panel capabilities.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide branch-circuit overcurrent protection.

C. Comply with requirements for branch-circuit protection and service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."

3.4 IDENTIFICATION

A. Identify system components according to Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Verify that certification labels are properly installed. Verify NFPA 110 compliance by validating that battery charger is listed to UL 1236 Category BBHH on the UL certification database.
2. Verify that connections are secure and in the proper locations. Ensure wiring is correctly connected between charger and battery.
3. Operational Test: After electrical circuitry has been energized, apply input voltage to confirm proper unit operation.
4. Test and adjust alarms, display indicators, controls, and safeties.

B. Battery charger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain battery chargers and related equipment.

B. Coordinate this training with that for emergency engine generator equipment.

END OF SECTION 263343

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UPS systems.
2. Surge suppression.
3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

B. Related Requirements:

1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 DEFINITIONS

A. GTO: Gate turn-off thyristor.

B. IGBT: Isolated gate bipolar transistor.

C. PF: Power factor.

D. pF: Picofarads.

E. THD: Total harmonic distortion.

1.3 SUBMITTALS

A. Product Data: For each type of UPS.

1. UPS systems.
2. Surge suppression.
3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

D. Manufacturers' published instructions.

E. Field Reports:

1. Factory test reports.
2. Manufacturer's field reports for field quality-control support.

1.4 CLOSEOUT SUBMITTALS

A. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Consumable Items:

1. After completion of field quality control, startup, commissioning, adjusting, and closeout activities, replace air filters.
2. Furnish to Owner extra consumable items for storage on-site, identified with labels describing contents. Include the following:

    a. Cabinet Ventilation Filters: One complete set(s).

1.6 WARRANTY FOR UPS SYSTEM

A. Special Manufacturer Extended Warranty: Manufacturer warrants that UPS system performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.

    1. Extended-Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.

1.7 WARRANTY FOR BATTERIES

A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended-warranty period.

    1. Initial Extended-Warranty Period for Ni-Cd Batteries: Five years from date of Substantial Completion; full coverage for materials only, free on board destination, freight prepaid.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

    1. Double Conversion, IGBT:

        a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output. High-efficiency carrier stored trench IGBT, in both rectifier-charger and inverter circuits, provides a minimum of 97 percent efficiency for the UPS system at full load and a minimum of 94 percent efficiency at 50 percent load.
        b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to provide constant, regulated inverter power output to the load.

c. Power Failure: If normal power fails, the rectifier-charger and inverter use energy from the battery to supply constant, regulated power output to the load without switching or disturbance.

2. When power is restored at the normal supply terminals of the system, controls must automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger must supply power to the load through the inverter and simultaneously recharge the battery.
3. If the battery becomes discharged and normal supply is available, the rectifier-charger must charge the battery. The rectifier-charger must automatically shift to float-charge mode on reaching full charge.
4. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch must switch the load to the normal AC supply circuit without disturbance or interruption.
5. The output power converters must produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter must sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
6. The inverter must be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
7. Should overloads persist past the time limitations, the automatic static transfer switch must switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch must return the load to the UPS system.
8. If the battery is disconnected, the UPS must supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal AC supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS AC input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS AC supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS AC supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

2.2 PERFORMANCE REQUIREMENTS

A. UL Compliance: Listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with UL 1778.

B. The UPS must perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state AC input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
4. Load is 50 percent unbalanced continuously.

C. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is 15 minutes.

D. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state AC input voltage varies plus 10 percent and minus 15 percent from nominal voltage.

E. Overall UPS Efficiency: Equal to or greater than 95 percent at 100 percent load, 94 percent at 75 percent load, and 93 percent at 25 percent load.

F. Maximum Energizing Inrush Current: Six times the full-load current.

G. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.

H. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.

I. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.

J. Limitation of harmonic distortion of input current to the UPS must be as follows:

1. Rectifier-charger circuits must limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
2. THD is limited to a maximum of 32 percent, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30.

K. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent RMS total and 3 percent RMS for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.

L. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.

M. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage must remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:

1. 50 Percent: Plus or minus 3 percent.
2. 100 Percent: Plus or minus 5 percent.
3. Loss of AC Input Power: Plus or minus 1 percent.
4. Restoration of AC Input Power: Plus or minus 1 percent.

N. Input Power Factor: A minimum of 0.90 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.

O. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging must not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:

1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.

P. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

2.3 UPS SYSTEMS

A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. APC by Schneider Electric.
3. Eaton.
4. Liebert; Vertiv Holdings Co.
5. Mitsubishi Electric Automation, Inc.
6. Staco Energy Products Co.
7. Toshiba International Corporation.

C. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

D. Enclosures: Comply with UL 50E, Type 1, unless otherwise indicated.

E. Configuration: Field-assembled, multicabinet modular style units.

F. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

G. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

H. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

I. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.

J. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

K. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.4 SURGE SUPPRESSION

A. Protect internal UPS components from surges that enter at each AC power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested in accordance with IEEE C62.41.1 and IEEE C62.41.2, Category B.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 400 Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

2.5 RECTIFIER-CHARGER

A. Description: Voltage source converter, six-pulse IGBT rectifier.

B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full

charge within 10 times the rated discharge time for duration of supply under battery power at full load.

C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

E. Battery Float-Charging Conditions: Comply with battery manufacturer's published instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger must be matched to the battery type supplied.

F. Ni-Cd Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging must be terminated when the rate of temperature rise reaches 1.8 deg F per minute. If the battery reaches 140 deg F prior to reaching this rate of temperature rise, charging must terminate. Chargers that determine full charge by voltage measurement to sense a 10 mV drop per cell when reaching full charge are also acceptable.

2.6 INVERTER

A. Description:

1. Pulse-width modulated, IGBT with sinusoidal output.

2.7 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: Plain-language messages on a digital LCD.

1. Quantitative indications must include the following:

a. Input voltage, each phase, line to line.
b. Input current, each phase, line to line.
c. Bypass input voltage, each phase, line to line.
d. Bypass input frequency.
e. System output voltage, each phase, line to line.
f. System output current, each phase.

g. System output frequency.
h. DC bus voltage.
i. Battery current and direction (charge/discharge).
j. Elapsed time discharging battery.

2. Basic status condition indications must include the following:

a. Normal operation.
b. Load-on bypass.
c. Load-on battery.
d. Inverter off.
e. Alarm condition.

3. Alarm indications must include the following:

a. Bypass AC input overvoltage or undervoltage.
b. Bypass AC input overfrequency or underfrequency.
c. Bypass AC input and inverter out of synchronization.
d. Bypass AC input wrong-phase rotation.
e. Bypass AC input single-phase condition.
f. Bypass AC input filter fuse blown.
g. Internal frequency standard in use.
h. Battery system alarm.
i. Control power failure.
j. Fan failure.
k. UPS overload.
l. Battery-charging control faulty.
m. Input overvoltage or undervoltage.
n. Input transformer overtemperature.
o. Input circuit breaker tripped.
p. Input wrong-phase rotation.
q. Input single-phase condition.
r. Approaching end of battery operation.
s. Battery undervoltage shutdown.
t. Maximum battery voltage.
u. Inverter fuse blown.
v. Inverter transformer overtemperature.
w. Inverter overtemperature.
x. Static bypass transfer switch overtemperature.
y. Inverter power supply fault.
z. Inverter transistors out of saturation.
aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls must include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts must be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.8 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.

2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch must be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch must electrically isolate other UPS components to permit safe servicing.
3. Switch must electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but must allow primary power to the UPS for testing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full-load UPS current.

D. Mounting Provisions: Internal to system cabinet.

E. Key interlock with key that is released only when the rectifier-charger and inverter are bypassed by the static bypass transfer switch. Key must be required to unlock maintenance bypass/isolation switch before switching from open (normal) position to

closed position. Lock must be designed specifically for mechanical and electrical component interlocking.

2.10 OUTPUT DISTRIBUTION SECTION

A. Panelboards: Comply with Section 262416 "Panelboards," except provide assembly integral to UPS cabinet.

2.11 REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicating five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.12 REMOTE MONITORING

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units for data transmission via TIA-485, Ethernet, or web-based link.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
3. Software and Hardware: Compatible with that specified in Section 260913 "Electrical Power Monitoring and Control."

2.13 BATTERY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. C&D Technologies, Inc.
2. Eaton.
3. EnerSys.
4. Exide Technologies.
5. Panasonic Corporation of North America.

B. General Characteristics:

1. Valve-regulated, heavy-duty, industrial, recombinant, pocket plate design, Ni-Cd units in polypropylene containers, complete with battery disconnect switch and intercell connectors.

    a. Factory assembled in an isolated compartment of UPS cabinet.
    b. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

C. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.

2.14 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Operation: Automatically measure and record each discharge event, classify it according to duration category and total discharges in accordance with warranty criteria, and display remaining warranted battery life on front panel display.

C. Additional monitoring functions and features must include the following:

1. Measuring and Recording: Total voltage at battery terminal. Initiate an alarm for excursions outside the proper float-voltage level.
2. Monitoring: Ambient temperature at battery; initiate an alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provide access to monitored data using front panel display.
4. Alarm Contacts: Arrange to initiate remote alarm for battery discharge events.
5. Memory: Store recorded data in nonvolatile electronic memory.
6. Ethernet Port: Permits downloading of data to a PC.

2.15 SOURCE QUALITY CONTROL

A. Product Data: Prepare and submit catalog cuts, brochures, diagrams, schedules, and performance data illustrating size, physical appearance, and other characteristics of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Product Certificates: For each product, from manufacturer.
4. Sample Warranties: For manufacturer's special warranties.

B. Factory Tests:

1. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
2. Factory Tests and Inspections: Test and inspect UPS system, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with NETA ATS before delivering to site. Affix label with name and date of manufacturer's certification of system compliance.

    a. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation. Include the following:

        1) Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
        2) Full-load test.
        3) Transient-load response test.
        4) Overload test.
        5) Power failure test.

3. Nonconforming Work:

    a. Equipment that does not pass tests and inspections will be considered defective.

4. Factory Test Reports: Prepare and submit factory test and inspection reports. Include the following data:

    a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
    b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
    c. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection in accordance with Section 262813 "Fuses" if required for coordination with UPS overcurrent protective device requirements.

3.2 INSTALLATION

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
   1. Comply with requirements for raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems."

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

C. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around the full perimeter of concrete base 6 inch from the outer edge of the base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and NFPA 70.

E. Connections: Interconnect system components. Make connections to supply and load circuits in accordance with manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

3.3 GROUNDING

A. Separately Derived Systems:

   1. If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
   2. If part of a listed power supply for a data-processing room, comply with manufacturer's published instructions that include grounding requirements in excess of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify each battery cell individually.

3.5 BATTERY EQUALIZATION

A. Equalize charging of battery cells in accordance with manufacturer's published instructions. Record individual-cell voltages.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect interiors of enclosures, including the following:

a. Inspect anchorage, alignment, grounding, and required clearances.
b. Component type and labeling verification.
c. Ratings of installed components.

2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:

a. Use of low-resistance ohmmeter in accordance with Section 7.22.2.2 of NETA ATS.
b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published instructions or Table 100.12 of NETA ATS.
c. Perform thermographic survey in accordance with Section 9 of NETA ATS.

4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test DC undervoltage trip level on inverter input breaker. Set in accordance with manufacturer's published instructions.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published instructions. In the absence of manufacturer's published instructions, use Table 100.1 of NETA ATS.
b. Perform insulation-resistance tests on all control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V

rated cable. Test duration must be one minute. For units with solid-state components, follow manufacturer's recommendation.

c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup, Use secondary current injection to test trip functions.
d. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published instructions.
e. Verify operation of charging mechanism.
f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.

8. Test automatic transfer switches.

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with Section 7.22.3.1 of NETA ATS.
b. Perform insulation-resistance tests on all control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
c. Perform a contact/pole-resistance test.
d. Verify settings and operation of control devices.
e. Calibrate and set all relays and timers in accordance with Section 7.9 of NETA ATS.
f. Verify phase rotation, phasing, and synchronized operation as required by the application.
g. Perform automatic transfer tests.

1) Simulate loss of normal power.
2) Return to normal power.
3) Simulate loss of emergency power.
4) Simulate all forms of single-phase conditions.

h. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Time delay on transfer.
3) Alternative source voltage-sensing and frequency-sensing relays.
4) Automatic transfer operation.
5) Interlocks and limit switch function.
6) Time delay and retransfer on normal power restoration.

9. Test direct current system's batteries.

a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.

b. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
c. Verify all charger functions and alarms.
d. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
e. Perform a load test in accordance with manufacturer's published instructions or IEEE 450.
f. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
g. Test values.

1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Charger float and equalize voltage levels must be in accordance with battery manufacturer's published instructions.
3) The results of charger functions and alarms must be in accordance with manufacturer's published instructions.
4) Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published instructions.
5) Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
6) Results of load tests must be in accordance with manufacturer's published instructions or IEEE 450.

10. Test communication of status and alarms to remote monitoring equipment.
11. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months in accordance with NIST standards.

a. Simulate malfunctions to verify protective device operation.
b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
d. Test output voltage under specified transient-load conditions.
e. Test efficiency at 50, 75, and 100 percent of rated loads.
f. Test remote status and alarm panel functions.
g. Test battery-monitoring system functions.

B. Seismic-restraint tests and inspections must include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
2. Test mounting and anchorage devices in accordance with requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Nonconforming Work:

1. The UPS system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Include references to manufacturers' published instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

3.7 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated for each UPS system.

B. Monitoring and Testing Schedule: Perform monitoring and testing in four 10-day periods, each in a different season of the year.

1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments must provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments must monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments must be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

1. Current: Each phase and neutral and grounding conductors.
2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.
5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.
10. Battery cell temperature during charging.
11. Ambient temperature.

D. Monitoring and Testing Procedures for Each Test Period:

1. Exploratory Period: For the first two days of the first scheduled monitoring and testing period, make recordings at various circuit locations and with various

parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.

2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

    a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
    b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period in accordance with directions of Owner's power quality specialist.
    c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
    d. Using loads and devices available as part of the facility's installed systems and equipment, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    e. Using temporarily connected resistive/inductive load banks, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    f. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing; repeat appropriate monitoring and testing to verify success of corrective action.

E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed in accordance with this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.

3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist must design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in each report:

1. Descriptions of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendations for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

END OF SECTION 263353

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Switchgear enclosure.
2. Switchgear construction.
3. Automatic Transfer Control
4. Surge arresters.
5. Instruments.
6. Protective relays.
7. Control power supply.
8. Battery system control power supply.
9. Control network.
10. Warning labels and signs.

B. Drawings EP-505, EP-701, EP-703 and EP-716

1.2 DEFINITIONS

A. ATS: Acceptance Testing Specification.

B. BIL: Basic Impulse Insulation Level.

C. DDC: Direct digital control.

D. HMI: Human Machine Interface (also see OIT)

E. Legally Required: As used in this Section, it shall have the same meaning as used in NFPA 70.

F. NETA ATS: Inter National Electrical Testing Association, Acceptance Testing Specification.

G. NiCad: Nickel Cadmium.

H. OIT: Operator Interface Terminal

I. SCADA: Supervisory Control and Data Acquisition

J. SCR: Silicon-controlled rectifier.

K. SPD: Surge protective device.

1.3 SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data on features, performance, electrical characteristics, ratings, and finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, SCADA interface devices, Ethernet interface, and display components.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: For each medium-voltage, metal-clad switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations must show major components, features, and mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of field connection. Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Accessory information for items such as circuit breaker test set, breaker remote racking assembly, breaker lifting cart, yoke and spare equipment storage cabinet.
6. Include single-line diagram.
7. Provide dimensioned drawings and details for the HMI/OIT standalone remote cabinet.
8. Provide battery sizing and load profile system report. Battery system shall be coordinated with specification 261327, Medium Voltage, Paralleling Metal-Clad switchgear, battery system.
9. Include copy of nameplate.
10. Ratings for the switchgear assembly:

    a. Voltage.
    b. Continuous current.
    c. Short-circuit current.
    d. Lightning impulse full-wave withstand voltage.

11. Include protection relay equipment information and base Relay settings used for factory testing.
12. CT, PT and LA (Lightning Arrestor) sizes and information.
13. Wiring Diagrams: For each switchgear assembly include the following:

    a. Power, signal, and control wiring.
    b. Differentiate between manufacturer-installed and field-installed wiring.
    c. Three-line diagrams of circuits showing device terminal numbers and internal diagrams.

d. Schematic control diagrams.
e. Control power wiring diagrams.
f. Diagrams showing connections of component devices and equipment.
g. Communication block wiring diagram
h. Schematic diagrams showing connections to remote devices including connection details to the communications network.
i. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

14. Mimic-bus diagram.
15. Provide spreadsheet table form list identifying all the metering and status points for gear devices and breakers. In table include columns for communication method and connection to locations (gear internal, remote HMI/OIT, SCADA and BMS).

C. Product Certificates: For switchgear and batteries, signed by product manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Updated mimic bus diagram reflecting field changes after final switchgear load connections have been made, for record.

B. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to Operation and Maintenance Data, include the following:

1. Manufacturer's written instructions for testing and adjusting protective relay devices.
2. Manufacturer's written instructions for sequence of operation.
3. Manufacturer's system checklists, maintenance schedule, and maintenance log sheets.
4. Lists of spare parts and replacement components recommended for storage at Project site.
5. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.

C. Software and Firmware Operational Documentation: Provide PDF files on a USB storage device.

1. Software operating and upgrade manuals.
2. Program Software Backup, complete with data files.
3. Device address list.
4. Printout/Screen Shots of software application and graphic screens.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Six of each type and rating of fuse and fusible device used. Include spares for the following:

a. Primary disconnect fuses.
b. Potential transformer fuses.
c. Control power fuses.

2. Spare Indicating Lights: Six of each type installed.
3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
4. Primary Switch Contact Lubricant: One container.
5. Cabinet: Floor standing self-supporting hinged door cabinet sized to house maintenance materials, equipment O&M manuals and miscellaneous switchgear specific tools.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with install contractor to deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate with install contractor for delivery of medium voltage metal clad switchgear to allow movement into designated space.

C. Coordinate with install contractor for offloading requirements at destination.

D. Provide manufacturer's temporary heating requirement and written instructions to installing contractor.

E. Provide manufacturer's written instructions to handle switchgear splits and components. Provide factory-installed lifting provisions.

F. Provide transportation shock recorders and tilt indicators with each shipping split. Provide written tolerance requirements for each indicator type.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding 104 deg F (40 deg C).

1.8 WARRANTY

A. Manufacturer's Warranty Period: Manufacturer's maintenance and service organization shall provide a warranty of five (5) years from date of startup commissioning. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming, or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include required system hardware, software and programming updates.

E. Warranty shall include coverage for labor, material and expense costs to correct all defects.

F. Warranty requirements specified in the Owner's contract documents which are more stringent than those listed in this specification shall override these requirements.

G. Original equipment repair parts shall be available for a minimum of 10 years.

H. Special Battery Warranties: Manufacturer and Installer agree to repair or replace the switchgear control system storage batteries that fail in materials or workmanship within specified warranty period. Warranty of five (5) years from date of startup commissioning.

1. Warranted Cycle Life for Batteries: Equal to or greater than that represented in manufacturer's published table, including discharge rate, voltage and discharge cycles, based on annual average battery temperature of 77 deg F (25 deg C).

1.9 START-UP

A. Provide manufacturer certified field service technician(s) required for a complete installation. To include switchgear field programming adjustments, breaker/protection relay setting adjustments, start up, field quality control and commissioning of equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufactured Unit: Indoor, metal-clad switchgear, designed for application in solidly grounded neutral system.

B. Comply with IEEE ANSI C37.20.2.

C. The switchgear ratings must comply with IEEE ANSI C37.04 and must be the preferred ratings of IEEE ANSI C37.06.

D. UL Listed 1008A

E. Switchgear Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory, and marked for intended location and application.

F. Comply with NFPA 99 - Essential Electrical Systems for Health Care Facilities.

G. Comply with NFPA 110 - Emergency and Standby Power Systems.

2.2 MANUFACTURERS

A. ABB / Zenith

B. ASCO / Schneider Electric

C. Russelectric / Siemens

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means the switchgear will remain in place without separation of any parts when subjected to the seismic forces specified and the switchgear will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Service Conditions:

1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.2.

2.4 SWITCHGEAR ENCLOSURE

A. Indoor Enclosure: Steel.

B. Enclosure Finish: Indoor Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 SWITCHGEAR CONSTRUCTION

A. Dead front, metal-clad, draw out, switchgear assembly of vertical sections, with vacuum circuit breakers. Provide additional vertical sections to house accessories related to the switchgear functions.

1. Front and rear access switchgear.
2. Front and rear vertical section covers with hinges. The front and rear cover must be a flanged door with latching hardware. The latching hardware shall be lockable by a padlock suitable for lockout protection.
3. Infrared Window: Each breaker compartment shall contain round window ports. The ports shall be 4”. The window ports quantity and locations for each breaker must be positioned to provide optimal viewing with external infrared camera.

B. Bus: Tin-plated copper.

1. Phase Bus: 1200A, epoxy insulated bus. All bus joints shall be plated, bolted and insulated with easily installed boots.
2. Ground Bus: Sized to carry the rated short-time withstand current, extended full length of the switchgear assembly, and connected to the metal enclosures of each vertical section.
3. Grounding Stud Ball: Each rear cabinet shall include a grounding stud ball connection for safety grounding. Provide hot-stick removable insulated ball cover.

C. Circuit Breaker Compartments: Include a racking mechanism, circuit breaker operated automatic shutters covering the high-voltage bus connections, safety interlocks, and an electrical racking motor and accessories for remote racking of the circuit breaker.

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of the breaker. Disconnecting devices shall be gold plated, and engagement shall be maintained in the "connected" and "test" positions.
4. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.
5. All space for circuit breaker shall be fully bussed and dressed to receive future breakers.
6. Complete operation of the circuit breaker and trip unit must be accessible without opening the circuit breaker door.
7. Padlocking provisions shall permit locking the circuit breaker in either the “test” or “disconnected” position.
8. Safety shutters shall be provided to cover the circuit breaker primary line and load disconnects.
9. Each circuit breaker compartment shall contain a rejection feature that allows only the insertion of an intended circuit breaker.
10. All circuit breakers of like size and ratings shall be completely interchangeable.
11. Each compartment shall contain Shutter-less Wall/Barriers that provides a physical touch-safe barrier between the busbars and operator.

D. Auxiliary Vertical Sections and Compartments:

1. Owner's Metering: A vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.
2. Remote HMI/OIT Cabinet: Provide standalone / remote vertical section to house the remote HMI/OIT system.

    a. Provide one (1) complete stand-alone control cabinet for remote breaker operation. Cabinet shall include an HMI/OIT panel with virtual breaker control. For virtual control include a verification step in “Open” and “Close” sequence to avoid nuisance operations.
        1) One HMI/OIT panel for the MV-ATS IUH-EQ and MV-ATS IUH-OS gear.
        2) One HMI/OIT panel for the MV-ATS CUP-Mech and MV-ATS UP-CH gear.

E. Circuit Breakers: Horizontally mounted, drawout, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

1. Electrically Operated: 125V(dc) close and trip. Powered from an external power source.

F. Accessory Set: Tools and miscellaneous items required for switchgear test, inspection, maintenance, and operation.

1. One of each size handling device to remove the circuit breaker from metal-clad switchgear and to move the breaker about on the floor. Devices include but are not limited to a floor operated portable lifting crane, breaker lifting yoke, rail extensions and dockable dolly.
2. Test cabinet with accessories to connect to the secondary contacts on an electrically operated removable element, permitting operation and testing of the removable element when it is removed from the housing.

G. Remote-Breaker Racking:

1. Provide two (2) complete automated remote racking systems for 15KV circuit breakers.
2. Remote racking device provides a means of remotely inserting or removing draw out circuit breaker in the switchgear.

a. A remote racking device shall be supplied to allow qualified personnel to rack breakers into Connect, Test and Disconnect positions from up to 25 feet away from the breaker and outside the arc flash hazard boundary.
b. The remote racking device shall support utilization on any Frame Size.
c. The remote racking device shall be portable and weigh less than 30 pounds (excluding cables and remote-control panel).
d. The remote racking device shall have integral torque overload sensing to prevent damage to the breaker racking mechanism.
e. The remote racking device shall allow breaker to be racked to any position (disconnect, test, connect) regardless of the starting position of the breaker and without the need for user input as to the starting position.
f. The 120v remote breaker racking device shall be attached to the factory mounted switchgear brackets (field retrofit capable) and secured by locking pins. No modification of the gear or circuit breakers shall be required for installation or operation.

H. Capacities and Characteristics:

1. Comply with IEEE ANSI C37.06.
2. Switchgear Assembly:

a. System Voltage 13.2KV, three-phase.
b. Rated Maximum Design Voltage and BIL (Dielectric Test): 15 kV, 95 kV.
c. Rated Continuous Current: 1200 A.
d. Rated Short-Circuit Current and Short-Time Current: 40 kA RMS.
e. Power Frequency Withstand: 36 KV.
f. Momentary Current Ratings: Equal to the circuit breaker close and latch rating.

3. Circuit Breakers:

   a. Same capacities and characteristics as the switchgear assembly, and as follows:

      1) Rated Continuous Current and Load Switching Current:
         a) Main, Tie and By-pass: 1200 A.
         b) Feeder: 1200A.
      2) Rated Closing and Latching Current: 104 kA, peak.
      3) Rated Interrupting Time: 50 ms.

   b. Breaker control and status indication for each breaker.

      1) Trip, Close, and Pull to Lock Switch
      2) Closed LED – Red
      3) Open LED – Green
      4) Tripped LED – Amber

2.6 AUTOMATIC TRANSFER

A. Comply with Level 1 equipment according to NFPA 110.

B. Digital Communication Interface: Matched to capability of Paralleling Switchgear and Master Control panel. Capable of Modbus TCP/IP communication (Quad Ethernet Ports and RS-485).

C. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

D. Terminal provisions for a remote contact which opens to signal, the transfer switch to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or remotely from the SCADA Mater Controller.

E. System LCD controller/display. Shall include the following features:

   1. System status screen which shall be readily accessible from any point in the menu by depressing the “ESC” key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. For example:

      a. Normal Failed
      b. Normal Bypass Closed
      c. Load on Normal

d. TD Normal to Emergency (X min X seconds)

2. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in an operator's manual, are not acceptable.

3. Self Diagnostics: The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being complete.

4. Data Logging: The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in non-volatile memory:

   a. Date and time and reason for transfer normal to emergency
   b. Date and time and reason for transfer emergency to normal
   c. Date and time and reason for normal fail
   d. Date and time and reason for normal bypass closed
   e. Date and time and reason for emergency fail
   f. Date and time and reason for emergency bypass closed
   g. Date and time and reason for engine start.
   h. Date and time engine stopped.
   i. Date and time emergency source available.
   j. Date and time emergency source not available.

5. Statistical Data:
   a. Total number of transfers.
   b. Total number of transfers due to source failure.
   c. Total number of days controller is energized.
   d. Total number of hours both normal and emergency sources are available.

F. One set of double pole, double throw contacts that operate when normal source voltage is available and one set of double pole, double throw contacts that operate when emergency source voltage is available.

G. Load Shedding circuit. 24VDC is acceptable. Manufacturer shall provide 24VDC system.

2.7 SURGE ARRESTERS

A. Comply with IEEE ANSI C62.11, station class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

2.8 INSTRUMENTS

A. Instrument Transformers: Comply with IEEE ANSI C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

B. Power Distribution Equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet.

C. Ethernet Connectivity: Gear Supplier shall provide their standard communication network to comply with the performance of this sub-paragraph.

1. Install a multipoint, Modbus TCP communications network, by suppling manufacturer standard within the switchgear to interconnect all breaker trip units, and metering devices equipped with communications.
2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.
3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-T LAN.
4. All serial communications devices within the equipment shall be addressed at the factory and tested.
5. The supplier has option to provide Modbus TCP/IP over Ethernet direct to each breaker in lieu of serial Modbus and gateways.

D. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Three-Phase Apparent Power: Plus or minus 2 percent.
g. Power Factor: Plus or minus 2 percent.
h. Frequency: Plus or minus 0.5 percent.
i. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
j. Energy: Watts, Watt Demand, Watt-hours, VARs, VAR Demand, VAR-Hour, VA, VA Demand and VA-Hour.
k. Accumulated energy, in megawatt-hours (megajoules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Event Waveform Capture shall record the voltage and current waveforms for each event exceeding settable thresholds. stored values unaffected by power outages for up to 72 hours.
4. Communications module suitable for remote monitoring of meter quantities and functions. Information to be communicated in Modbus TCP/IP over Ethernet. Connections to HMI / OIT, SCADA, BMS and downloadable to USB Drive.
5. Mounting: Display and control unit that is flush or semi flush mounted in instrument compartment door.
6. Provide metering for each circuit breaker installed.

E. Analog Instruments: Rectangular, 4-1/2 inch (115 mm) square, 1 percent accuracy, semi flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase voltages.
3. Locate meter and selector switch on circuit-breaker compartment door for Main and Tie Breakers only.

2.9 PROTECTIVE RELAYS

A. Multifunctional, solid-state microprocessor-based relay systems, complying with IEEE ANSI C37.90.

B. Relay Mounting:

1. Each relay must be panel mounted.
2. Removal of the relay must disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.
3. When the relay is inserted and reconnected, control power connections must be made before the trip circuits are activated.
4. Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.
5. Provide required CT and PT and wiring to each digital protective relay.
6. Provide fiber optic arc flash detection sensors, wiring and connections as required for arc flash detection coverage of each corresponding side of the switchgear. Set for flash and current rate of rise.
7. Provide maintenance setting switch on protective relay to reduce arc flash hazard when the switch is in the maintenance mode position.
8. Manufacturer must provide initial protection relay settings to complete factory testing.
9. The manufacturer field technician onsite must complete relay setting adjustments required to meet the field quality control startup and commissioning.

C. Each relay system must include a communications module to transmit data.

1. Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.

2. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

D. Overcurrent and Ground-Fault Protective Relays:

1. IEEE ANSI C37.2 and ANSI device functions as specified for each type of load. The basis of design manufacturer is SEL.
2. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.
3. Primary Current-Transformer Ratings: Programmable from 5 to 2000 A.
4. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
5. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and must be deactivated after approximately eight cycles.
6. Contacts:

    a. Two Form-A contacts.
    b. Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

        1) One contact assigned function 51 phase and function 51 ground, and the other contact assigned function 50 phase and function 50 ground.
        2) One contact assigned function 51/50 phase, and the other contact assigned function 51/50 ground.

7. Alphanumeric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current-causing trip.
    e. Phase or ground indication.
    f. Peak current demand for each phase and ground since last reset.
    g. Current-transformer primary rating.
    h. Programmed phase and ground set points.

8. Relay alarm and trip contacts must not change state if power is lost or an undervoltage occurs. These contacts must only cause a trip on detection of an overcurrent or fault condition based on programmed settings. A "protection off" alarm must be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this alarm relay must be de-energized, providing a fail-safe protection off alarm.

E. Switchgear shall include following type, rating and protection relay: SEL Relays identified as Base-Line.

1. Normal, Emergency and Bypass Circuit Breakers: SEL 751A - ANSI 25, 27, 47, 50/51P, 50/51N, 50/51G, 50/51PAF and 86.
2. Feeder Circuit Breaker: SEL 751A - ANSI 50/51P, 50/51G, 50/51PAF and 86.

F. Power Transfer Configuration for Normal – Bypass – Emergency - Bypass:

1. Automatic Transfer Control: Must have a microprocessor-based automatic transfer control scheme with auto/manual selector.
2. Factory-installed and tested controls of circuit breakers to accomplish automatic transfer controls for switchgear having normal and emergency power sources.

    a. Normal operation is Normal breaker “Closed” operating on Normal source power.
    b. If Normal breaker fails, the Normal Bypass breaker shall be utilized.
    c. Normal source power loss, MV-ATS controller shall send engine start signal to Paralleling Switchgear (PS) Master Controller to start generators. MV-ATS controller shall transfer to Emergency source. Closing of the Emergency Breaker shall be time delayed coordinating with the emergency generator sequencing. Time delay shall be adjustable between 0 and 180 seconds.
    d. Return to Normal source: MV-ATS controller shall sync (ANSI No. 25) Emergency and Normal through the PS Master Controller. Closed transition operation, 100Msec overlap.

3. Power for the transfer control shall be from the voltage sensing transformers.
4. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative sequence voltage protection.
5. The transfer control system shall be indicated on the HMI dashboard. The dashboard shall show the status of the system as it is operating. When timers are functioning, the dashboard shall show the timer counting down.

G. Arc Flash protection shall be provided by the protection relay. System shall include one style or a combination of both fiber optic cable and fiber optic point sensors. Trip identification shall include both light flash and current rate of rise.

H. Indicating Lights(LED): To indicate circuit breaker is open or closed. To indicate on Normal or Emergency Source.

I. Test Switch: Simulate normal-source failure.

J. Switch-Position Pilot Lights (LED): Indicate source to which load is connected.

K. Source-Available Indicating Lights (LED): Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

1. Normal Power Supervision (LED): Green light with nameplate engraved "Normal Source Available."
2. Emergency Power Supervision (LED): Red light with nameplate engraved "Emergency Source Available."

L. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

M. Bypass/Isolation function shall be provided using a second set of MV Vacuum breakers with redundant controls.

N. Dual redundant ATS Controllers shall be provided. In the event of a control panel failure the second control panel shall assume all switching functions.

2.10 DC CONTROL POWER SUPPLY

A. DC Power Control System for MV-ATS gear shall be sized and included with the specification 261327, Medium Voltage, Paralleling Metal-Clad switchgear, battery system. The following parameters describe the DC Control Power System.

B. Manufacturers:

1. EnerSys
2. Saft
3. SBS
4. SENS
5. Approved Equal

C. Dedicated 125 V(dc) battery system.

D. System Requirements: Battery must have number of cells and ampere-hour capacity based on an initial specific gravity at 77 deg F (25 deg C) with electrolyte at normal level and minimum ambient temperature of 55 deg F (13 deg C). Cycle battery before shipment to guarantee rated capacity on installation. Arrange to operate ungrounded. Battery system capacity must be as recommended by switchgear manufacturer to operate the circuit breakers and switchgear control for intended duty.

1. Battery system must be fully redundant with separate battery racks and chargers. Each system sized for 100% operation.

    a. Size system for two complete trip charge operations for each breaker. Once at loss of Utility power and once after eight hours of maintained steady state operation.

2. Provide battery sizing and load profile system report.

E. Battery: Ni-Cd system is the basis of design. Li-ion system is an acceptable alternative.

1. Batteries, with system disconnect and overcurrent protective device.
2. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.
3. Accessories: Set of battery cell numerals.
4. Charger: Solid State Switched Mode type equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit must automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

    a. DC ammeter.
    b. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
    c. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
    d. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
    e. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation must be automatic until manually reset.
    f. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3 Hz variation in frequency. Automatic charger operation must resume after loss of ac power supply for interval.
    g. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device must regulate charging current but must not disconnect charger from either battery or ac supply.
    h. Charger's Audible Noise: Less than 26 dB.

F. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

G. Battery Cell Monitoring System with normal/trouble/alarm communication to SCADA and BMS systems.

H. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

1. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
2. Conductors: Sized in accordance with NFPA 70 for duty required.

2.11 IDENTIFICATION, WARNING LABELS AND SIGNS

A. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for OSHA 29 CFR 1910.269.

1. Warning signs must be baked enamel signs.
2. Equipment Identification Labels: Laminated acrylic or melamine plastic signs.

B. Compartment Nameplates: Engraved, metal nameplate for each compartment, mounted with corrosion-resistant screws.

C. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
2. Color: Contrasting with factory-finish background.

2.12 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS.

B. Perform production tests on each circuit breaker housing for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
2. Conduct an alignment test with master circuit breaker to verify interfaces.
3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
4. Perform the control wiring dielectric test at 1500 V for one minute.
5. Perform the dielectric test on primary and secondary circuits.

C. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of the switch.
2. Conduct an alignment test with master cell to verify interfaces and interchangeability.
3. Verify the contact gap. Perform terminal-to-terminal resistance test.
4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.
5. Perform the control wiring dielectric test at 1500 V for one minute.
6. Set the contact gap.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Provide factory certified technician(s) to complete tests, adjustments and inspections. See above, Part 1 - 1.08 Warranty and Part 1 – 1.09- Start-Up.

3.2 SYSTEM FUNCTION COMMISSIONING TESTS

A. Manufacturer's Field Service: Provide factory-authorized service technician(s) to provide startup and commissioning of MV-ATS switchgear.

1. Services to include service technician(s) being on site as each circuit breaker is energized to test programing and functionality.
2. Test automatic transfer control scheme.
3. Provide documentation confirming results of testing.
4. Provide field programming and relay setting adjustments required to complete field quality control, startup and commissioning.

B. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Provide test parameters documents and submit to Owner/Project Representative minimum of eight (8) weeks prior to testing for review and approval.
2. Perform approved submittal tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
3. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
4. Verify the correct operation of sensing devices, alarms, and indicating devices.

C. Provide complete startup and commissioning test report for switchgear.

3.3 FACTORY WITNESS TEST

A. The medium voltage switchgear manufacturer shall include in the proposal a factory witness test that provides testing of the switchgear lineup, including failure recovery operations. The manufacturer shall provide the ability to simulate source loss, circuit breaker failure and undervoltage and overload events. Factory testing schedule shall be provided minimum of four weeks prior to testing for coordination of travel accommodations. The proposal shall include Owner travel expenses:

1. Include costs associated with Owner travel expense to witness factory testing. Total value attributed to travel expense shall be clearly indicated.
2. Expenses shall include roundtrip coach airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town

ground transportation, and all associated taxes and fees.

3. Exclude other incidental expenses not indicated.
4. Include travel expenses for two Owner Representatives, with origin of Indianapolis, IN.

END OF SECTION 263600

SECTION 263600.1 - MEDIUM-VOLTAGE, AUTOMATIC TRANSFER SWITCHGEAR - INSTALL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Installation of Medium Voltage Switchboards

B. Related Requirements:
   1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   2. Section 261327 “Medium-Voltage Paralleling Metal Clad Switchgear” Purchase and Install.
   3. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in switchgear.

1.2 DEFINITIONS

A. NETA ATS: International Electrical Testing Association, Acceptance Testing Specification.

1.3 SUBMITTALS

A. Product Data: For each type of product.

   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Field Connection Wiring Diagrams: Power, signal, and control wiring.
   2. Dimensioned plans and elevations showing major components and features.

      a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.
   3. One-line diagram.
   4. List of materials.
   5. Nameplate legends.

C. Field quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of switchgear to allow movement into designated space.

C. Store switchgear components protected from weather and so condensation does not form on or in units. Provide temporary heating in accordance with manufacturer's instructions.

D. Handle switchgear components in accordance with manufacturer's instructions. Use factory-installed lifting provisions.

1.5 WARRANTY

A. Installer’s Warranty Period: Provide a warranty for one year from the date of substantial completion. Warranty shall correct defects due to the following:

1. Failure to comply with specifications.
2. Faulty materials, equipment, appliances, programming or other items.
3. Faulty workmanship.

B. Defects corrected after energizing shall be accomplished at a time agreeable to Owner.

C. Defects shall be corrected without charge to Owner.

D. Warranty shall include coverage for labor, material and expense costs to correct all defects.

E. Warranty requirements specified in the Owner’s contract documents which are more stringent than those listed in this specification shall override these requirements.

PART 2 - PRODUCTS

2.1 Provide Gear Maintenance Cabinet: Identified and compartmented steel cabinet with lockable hinged doors. Sized for breaker remote racking out devices, breaker test devices, flexible cord sets and miscellaneous gear equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.

1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.
2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and shop drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
5. Unload switchgear, observing packing label warnings and handling instructions.
6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle switchgear in accordance with manufacturer's recommendations, avoid damage to the enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
2. Protect switchgear compartments against the entrance of dust, rain, and snow.
3. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
4. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
5. Do not damage structure when handling switchgear.

C. Storage:

1. Store switchgear in a location that is clean and protected from weather. Protect switchgear from dirt, water, contamination, and physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
2. Store switchgear with compartment doors closed.
3. Regularly inspect switchgear while in storage and maintain documentation of storage conditions, noting discrepancies or adverse conditions.

D. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

E. Pre-Installation Checks:

1. Verify removal of shipping bracing after placement.

F. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 ohms ohms at switchgear location.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SWITCHGEAR

A. Comply with the provisions of IEEE ANSI C37.20.2 subclause titled "Guide for Handling, Storage, and Installation."

B. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). See structural sheets for equipment base details.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Comply with requirements for vibration isolation devices specified in Section 260529 "Hangers and Supports for Electrical Systems."

C. Switchgear must be installed level and plumb. Switchgear must tilt less than 1.5 degrees while energized.

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's written instructions and NFPA 70.

E. Comply with NECA 430.

3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable not smaller than No. 4/0 AWG for grounding cabling to grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

D. Complete switchgear grounding and lightning arrester connections prior to making other electrical connections.

E. Terminate medium-voltage cables in accordance with Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Construction Manager Project Representative.

B. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

C. Medium-Voltage Switchgear Assembly Field Tests:

1. Visual and Mechanical Inspection:

    a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
    b. Verify that current and voltage transformer ratios correspond to Drawings.
    c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

        1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
        2) Make key exchange with devices operated in off-normal positions.

    e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    f. Inspect insulators for evidence of physical damage or contaminated surfaces.
    g. Verify correct barrier and shutter installation and operation.
    h. Exercise active components.
    i. Inspect mechanical indicating devices for correct operation.
    j. Verify that filters are in place and vents are clear.
    k. Perform visual and mechanical inspection of instrument transformers in accordance with "Instrument Transformer Field Tests" Paragraph.
    l. Inspect control power transformers.

        1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
        2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.
        3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

    a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.

e. Control Power Transformers:

1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at devices.
3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

f. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at devices.

2) Verify secondary voltages by energizing the primary winding with system voltage.

g. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Perform system function tests in accordance with "System Function Tests" Article.
i. Verify operation of space heaters.
j. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism must be in accordance with manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.

b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values must not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the trip and close coils must comply with manufacturer's published data. In the absence of the manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer's published data.
e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.
f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values must comply with manufacturer's published data.
g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.
h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
i. Verify operation of heaters.

E. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.
c. Verify correct connection of transformers with system requirements.
d. Verify that adequate clearances exist between primary and secondary circuit wiring.
e. Verify the unit is clean.
f. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

g. Verify that required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's written recommendations or NETA ATS, Table 100.5.
c. Perform a polarity test of each current transformer in accordance with IEEE ANSI C57.13.1. Polarity results must agree with transformer markings.
d. Perform an excitation test on transformers used for relaying applications in accordance with IEEE ANSI C57.13.1. Excitation results must match the curve supplied by the manufacturer or be in accordance with IEEE ANSI C57.13.1.
e. Measure current circuit burdens at transformer terminals in accordance with IEEE ANSI C57.13.1. Measured burdens must be compared with and must match instrument transformer ratings.
f. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages must be in accordance with Table 100.5.
g. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages must be in accordance with Table 100.9.
h. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
i. Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

3. Electrical Tests of Voltage Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages must be applied for one minute in accordance with Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.
c. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable. Polarity results must agree with transformer markings.
d. Measure voltage circuit burdens at transformer terminals. Measured burdens must be compared with and must match instrument transformer ratings.
e. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data. Power-factor or dissipation-factor values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.
f. Verify that voltage transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. Test results must indicate that the circuits are grounded at only one point.

F. Ground Resistance Test:

1. Visual and Mechanical Inspection:

a. Verify ground system complies with Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections must be free of corrosion.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
d. Inspect anchorage.

2. Electrical Tests:

a. Perform fall-of-potential or alternative test in accordance with IEEE Std 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground must be no more than 5 ohms.
b. Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohm. Compare equipment nameplate data with Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using a low resistance ohmmeter to compare bolted connection resistance values to

values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

G. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
c. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
d. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results must confirm the integrity of the secondary circuits of current and voltage transformers.

H. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
f. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

2. Electrical Test:

a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.
b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
c. Test grounding connections. Resistance between the arrester ground terminal and the ground system must be less than 0.5 ohm.

I. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded in accordance with manufacturer's instructions.
g. Set the relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.
b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) Sync Check Relay:

a) Determine closing zone at rated voltage.

b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

4) Undervoltage Relay:

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on the timing curve for inverse time relays.

5) Directional Power Relay:

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on the timing curve for inverse time relays.

6) Current Balance Relay:

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

7) Negative Sequence Current Relay:

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on the I-two-squared-t curve.

8) Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.

9) Time Overcurrent:

a) Determine minimum pickup.
b) Determine time delay at two points on the time current curve.

10) Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

11) Directional Overcurrent Relay:

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine overcurrent unit pickup.
d) Determine overcurrent unit time delay at two points on the time current curve.

d. Control Verification:

1) Functional Tests:

a) Check operation of active digital inputs.
b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

J. DC System Vented NiCd Batteries Field Test:

1. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify equipment nameplate data complies with Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify electrolyte level. Measure pilot-cell electrolyte temperature, and correct as recommended by manufacturer's maintenance procedures to bring the temperature and electrolyte level to within normal limits.
h. Verify the units are clean.
i. Inspect spill containment installation.
j. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and that alarms comply with system manufacturer's recommendations.
c. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published data.
d. Measure intercell connection resistances.
e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
f. Perform a load test in accordance with manufacturer's published data or IEEE Std 1106. Replace units that fail to pass the test.
g. Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive-to-ground must be equal in magnitude to the voltage measured from negative to ground.

K. Nonconforming Work:

1. Switchgear will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

L. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.6 SYSTEM FUNCTION TESTS

A. System function tests must prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, if requested by Owner, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each switchgear. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than

1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.

2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

    a. Adjust switchgear taps.
    b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.
4. Report:

    a. Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove covers prior to the inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 86 deg F.
3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used and lists the results as follows:

    a. Description of equipment to be tested.
    b. Discrepancies.
    c. Temperature difference between the area of concern and the reference area.
    d. Probable cause of temperature difference.
    e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
    f. Identify load conditions at time of inspection.
    g. Provide photographs and thermograms of the deficient area.

4. Act on inspection results in accordance with the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

END OF SECTION 261326.1

SECTION 263600.2 – LOW VOLTAGE TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. This specification is for 1000V or lower ATS. For voltages above 480V, see 263600 – Medium Voltage Automatic Transfer Switches.

B. Section Includes:

1. Contactor-type automatic transfer switches.
2. Molded-case-type automatic transfer switches.
3. Transfer switch accessories.

C. Related Requirements

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 SUBMITTALS

A. Product Data:

1. Contactor-type automatic transfer switches.
2. Molded-case-type automatic transfer switches.
3. Transfer switch accessories.

B. Product Data Submittals: For each product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

C. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.

3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

D. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for three cycles.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

L. Neutral Terminal: Solid and fully rated unless otherwise indicated.

M. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or

annunciator and control panels shall have communication capability matched with remote device.

N. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable tape shrinkable sleeve markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via front access.

O. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. Caterpillar, Inc.; Electric Power Division.
3. Cummins Power Generation.
4. Eaton.
5. Generac.
6. Hubbell Utility Solutions; Hubbell Incorporated.
7. Kohler Power Systems.
8. Rolls-Royce Solutions America Inc.
9. Russelectric, Inc.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Switch Action: Double throw; mechanically held in both directions.
2. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
3. Conductor Connectors: Suitable for use with conductor material and sizes.
4. Material: Hard-drawn copper, 98 percent conductivity.
5. Main and Neutral Lugs: Mechanical type.
6. Ground Lugs and Bus-Configured Terminators: Mechanical type.
7. Ground bar.
8. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

E. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
3. Test Switch: Simulate normal-source failure.
4. Switch-Position Pilot Lights: Indicate source to which load is connected.
5. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

6. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

7. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
8. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
9. Engine Shutdown Contacts:
   a. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

10. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

2.3 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. Caterpillar, Inc.; Electric Power Division.
3. Cummins Power Generation.
4. Eaton.
5. Emerson Electric Co., Automation Solutions.
6. Generac.
7. Kohler Power Systems.
8. Lake Shore Electric Corporation.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Switch Action: Double throw; mechanically held in both directions.
2. Contacts: Silver composition or silver alloy for load-current switching.
3. Conductor Connectors: Suitable for use with conductor material and sizes.
4. Material: Hard-drawn copper, 98 percent conductivity.
5. Main and Neutral Lugs: Mechanical type.
6. Ground Lugs and Bus-Configured Terminators: Mechanical type.
7. Ground bar.

8. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

E. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. Transfer Switches Based on Molded-Case-Switch Components: Comply with UL 489 and UL 869A.

I. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
3. Test Switch: Simulate normal-source failure.
4. Switch-Position Pilot Lights: Indicate source to which load is connected.
5. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

6. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
7. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
8. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
9. Engine Shutdown Contacts:
    a. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

10. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

2.4 TRANSFER SWITCH ACCESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

    a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
    b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
    c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
    d. Transition:

1) Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.

e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
g. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
h. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
i. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
j. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to equipment pad by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Structural Drawings and Specifications.
2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
4. Provide workspace and clearances required by NFPA 70.

B. Identify components according to Section 260553 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways specified in Section 260533 “Raceways and Boxes for Electrical Systems.”

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."

G. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

H. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

I. Final connections to equipment shall be made with liquid tight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:
1. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Tests and Inspections:

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with Drawings and Specifications.
b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and required clearances.
d. Verify that the unit is clean.
e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Verify that manual transfer warnings are attached and visible.
g. Verify tightness of all control connections.
h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

i. Perform manual transfer operation.
j. Verify positive mechanical interlocking between normal and alternate sources.
k. Perform visual and mechanical inspection of surge arresters.
l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

a. Perform insulation-resistance tests on all control wiring with respect to ground.
b. Verify settings and operation of control devices.
c. Calibrate and set all relays and timers.
d. Verify phase rotation, phasing, and synchronized operation.
e. Perform automatic transfer tests.
f. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Engine start sequence.
3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits.

Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
b. Verify time-delay settings.
c. Verify pickup and dropout voltages by data readout or inspection of control settings.
d. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
e. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Transfer switches will be considered defective if they do not pass tests and inspections.

F. Remove and replace malfunctioning units and retest as specified above.

G. Prepare test and inspection reports.

H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 263600.2

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes lightning protection system for ordinary structures.

1.3 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

C. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

D. Qualification Data: For Installer.

E. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:

1. UL Master Label Certificate.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: LPI Master Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Advanced Lightning Technology, Ltd.
2. East Coast Lightning Equipment Inc.
3. ERICO; a brand of nVent.
4. Harger Lightning & Grounding.
5. Heary Bros. Lightning Protection Co. Inc.
6. Independent Protection Co.
7. National Lightning Protection.
8. Thompson Lightning Protection, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:

1. Aluminum unless otherwise indicated.
2. 5/8-inch diameter by 24 inches long.
3. Solid with Rounded tip.
4. Integral base support.

B. Air Terminal Bracing:

1. Aluminum.
2. 1/4-inch diameter rod.

C. Class II Main Conductors:
1. Aluminum: 192,000 circular mils in diameter.

D. Secondary Conductors:
1. Aluminum: 41,400 circular mils in diameter.

E. Ground Loop Conductor: Stranded copper**.**

F. Ground Rods:

1. Material: Copper-clad steel.
2. Diameter: 3/4 inch.
3. Rods shall be not less than 120 inches long.

G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed systems in NFPA 780.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods

and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.

2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld or high compression crimp.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

1. Perform inspections as required to obtain a UL Master Label for system.
2. Perform inspections to obtain an LPI certification.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

SECTION 264313 - SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type 1 surge protective devices (SPDs).
2. Type 2 surge protective devices (SPDs).
3. Enclosures.
4. Conductors and cables.

B. Related Requirements:
1. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
2. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.

1.2 DEFINITIONS

A. I_n: Nominal discharge current.

B. Maximum Continuous Operating Voltage (MCOV): The maximum designated RMS value of the power frequency voltage that may be continuously applied to the mode of protection of an SPD.

C. Metal-Oxide Varistor (MOV): An electronic component with a significant bidirectional, nonlinear current-voltage characteristic.

D. Mode(s), Modes of Protection, or Protection Modes: Electrical paths where the SPD offers defense against transient overvoltage. Examples include line to neutral (L-N), line to ground (L-G), line to line (L-L), and neutral to ground (N-G).

E. SCCR: Short-circuit current rating.

F. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

G. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

H. Voltage Protection Rating (VPR): A rating selected from UL 1449 list of preferred values assigned to each mode of protection.

1.3 SUBMITTALS

A. Product Data:

1. For each type of product.

a. Include electrical characteristics, specialties, and accessories for SPDs.
b. Certification of compliance with UL 1449 by qualified electrical testing laboratory recognized by authorities having jurisdiction including the following information:

1) Tested values for VPRs.
2) I_n ratings.
3) MCOV, type designations.
4) OCPD requirements.
5) Manufacturer's model number.
6) System voltage.
7) Modes of protection.

B. Field quality-control reports.

1.4 WARRANTY

A. Special Manufacturer Warranty: Manufacturer warrants that SPDs perform in accordance with specified requirements and agrees to provide repair or replacement of SPDs that fail to perform as specified within extended warranty period.
1. Warranty Period: 10 year(s) from date of Substantial Completion, for materials only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB, Electrification Business.
2. Advanced Protection Technologies Inc. (APT).
3. Current technology: .
4. Eaton.
5. Intermatic, Inc.
6. LEA International: .

7. Leviton Manufacturing Co., Inc.
8. Liebert; Vertiv Holdings Co.
9. Mersen USA.
10. Schneider Electric USA, Inc.
11. Siemens Industry, Inc., Energy Management Division.
12. Surge Suppression Inc. (SSI).
13. Raycap, Inc.

B. Source Limitations: Obtain devices from single source from single manufacturer.

C. General Characteristics:

1. Reference Standards: UL 1449; UL 1283; Type 1.
2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.

3. SCCR: Not less than 200 kA.
4. I_n Rating: 20 kA.

D. Options Included:

1. Include integral disconnect switch.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include indicator light display for protection status.
4. Include audible alarm.
5. Include NEMA ICS 5, dry Form C contacts rated at 5 A and 240 V(ac) for remote monitoring of protection status.
6. Include surge counter with stamp.

2.2 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

A. Source Limitations: Obtain devices from single source from single manufacturer.
1. Peak Surge Current Rating for switchgear/switchboard: Minimum single-pulse surge current withstand rating per phase must not be less than300 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode. Minimum 10 mode protection.
2. Peak Surge Current Rating for Power Panelboard/Branch panelboard: Minimum single-pulse surge current withstand rating per phase must not be less than 150 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode. Minimum 10 mode protection.
3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:

a. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
b. Line to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
c. Neutral to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
d. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.

4. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:

    a. Line to Neutral: 700 V.
    b. Line to Ground: 700 V.
    c. Neutral to Ground: 700 V.
    d. Line to Line: 1200 V.

2.3 ENCLOSURES

A. Indoor Enclosures: Type 1.

2.4 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's instructions.

B. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
2. Do not exceed manufacturer's recommended lead length.
3. Do not bond neutral and ground.

C. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Construction Manager.

B. Tests and Inspections:

1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.

3. Verify that electrical wiring installation complies with manufacturer's installation requirements.

C. Nonconforming Work:

1. SPDs that do not pass tests and inspections will be considered defective.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's instructions.

B. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION 264313

SECTION 265119 - LED INTERIOR LIGHTING

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Downlight.
2. Highbay, linear.
3. Linear industrial.
4. Strip light.
5. Surface mount, linear.
6. Surface mount, nonlinear.
7. Reassessed, linear.
8. Materials.
9. Luminaire support.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests[**, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project**] [**IES LM-79**] [**and**] [**IES LM-80**].

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for lighting submittals.>

D. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

E. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

F. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

G. Product Schedule: For luminaires and lamps. **Use same designations indicated on Drawings.**

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which equipment and luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Sprinklers.
    d. Access panels.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each type of luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all LED types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Drivers: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications:

1. Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
2. Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

2. PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance:

1. Luminaires shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
2. Luminaires and lamps shall be labeled vibration and shock resistant.
3. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

B. Ambient Temperature: **41 to 104 deg F (5 to 40 deg C)**] .

1. Relative Humidity: Zero to 95 percent.

C. Altitude: Sea level to **1000 feet (300 m)**.

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following LED characteristics:

a. "USE ONLY" and include specific lamp type.
b. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.

D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. California Title 24 compliant.

2.3 DOWNLIGHT [F10A]

A. Alphabet NU6-ECO

B. Nominal Operating Voltage: 277 V ac.

C. LED:

1. Minimum 1025 lm.
2. Minimum allowable efficacy [80] of 68.33 lm/W.
3. CRI of minimum 80. CCT of 3500 K.
4. Rated lamp life of 49,500 hours to L70.
5. Dimmable from 1 percent of maximum light output.
6. Internal driver.

7. Lens Thickness: At least 1.2-mm minimum unless otherwise indicated.

D. Housings:

1. Electrocoated 16-gauge cold-rolled steel.
2. powder coated.
3. New construction Housing.
4. Integral junction box with conduit fittings.

E. Diffusers and Globes:

1. Fixed lens.
2. 60-degree distribution.
3. Diffuse clear lens.
4. Acrylic belzel

F. Standards:

1. ETLus Listed to UL1598, cETL Listed to CSA C22.2 #250.0
2. IP65 with lens - Suitable for wet locations with lens - Suitable for damp locations without lens
3. Non-conductive, Lexan dead-front construction - Made in the USA - meets the requirements of the Buy American provision within the ARRA

2.4 HIGHBAY, LINEAR [F1A-90]

A. Columbia ECH

B. Nominal Operating Voltage: 277 V ac.

C. Lamp:

1. Minimum 9,100 lm.
2. Minimum allowable efficacy of [90] 171 lm/W.
3. CRI of minimum 90 . CCT of 3500 K.
4. Rated lamp life of 60,000 hours to L93.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.
7. User-Replaceable LED boards:

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. extruded aluminum housing
2. powder coat paint
3. Cable mount option • Pendant mount available through 3/4" KO on back of housing • Surface mount brackets available
4. Integral junction box with conduit fittings.

E. driver cover door accessed from below

F. Diffusers and Globes:

1. Fixed lens.
2. Wide lens distribution.
3. polycarbonate lens
4. Acrylic diffuser

G. Standards:

1. All luminaires are built to UL 1598 standard.
2. Damp location.
3. DLC® (DesignLights Consortium) Qualified, with some Premium Qualified configurations.

2.5 HIGHBAY, LINEAR [F1A, F1B, F1C]

A. Columbia ECH

B. Nominal Operating Voltage: 277 V ac.

C. Lamp:

1. Minimum 12,000 lm.
2. Minimum allowable efficacy of [80] 160 lm/W.
3. CRI of minimum 80. CCT of 3500 K.
4. Rated lamp life of 60,000 hours to L93.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.
7. User-Replaceable LED boards:

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. extruded aluminum housing
2. powder coat paint
3. Cable mount option • Pendant mount available through 3/4" KO on back of housing • Surface mount brackets available
4. Integral junction box with conduit fittings.

E. driver cover door accessed from below

F. Diffusers and Globes:

1. Fixed lens.
2. Wide lens distribution.
3. polycarbonate lens
4. Acrylic diffuser

G. Standards:

1. All luminaires are built to UL 1598 standard.
2. Damp location.
3. DLC® (DesignLights Consortium) Qualified, with some Premium Qualified configurations.

2.6 LINEAR INDUSTRIAL [F4A]

A. SPECGRADE LED-ARIES-A

B. Nominal Operating Voltage: 277 V ac.

C. LED:

1. Minimum 8,692 lm.
2. Minimum allowable efficacy of [70] 140 lm/W.

3. CRI of minimum 70. CCT of 3500 K.
4. Rated lamp life of 85,000 hours to L70.
5. Internal driver.

6. Lens Thickness: At least 11-inch (2.5-mm) minimum unless otherwise indicated.

D. Housings:
1. A383 die cast Aluminum
2. powder coated

E. Diffusers and Globes:

1. Fixed lens.
2. Wide distribution
3. polycarbonate lens

1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. Class I Division 2, Groups A, B, C, D - Class II Division 1, Groups E, F, G - Class II Division 2, Groups F, G - Class III
2. IP66 Rated
3. IK10 Rated
4. NEMA 4X

2.7 LINEAR INDUSTRIAL [F6, P1]

A. COLUMBIA LEXM

B. Nominal Operating Voltage: 277 V ac.

C. LED Module:

1. Minimum 5,037 lm.
2. Minimum allowable efficacy of [80] 84 lm/W.
3. CRI of minimum 780. CCT of 3500 K.
4. Rated lamp life of 60,000 hours to L80.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.

7. Lens Thickness: At least 11-inch (2.5-mm) minimum unless otherwise indicated.

D. Housings:
1. UL 5VA fiberglass housing with F1 weatherability rating

2. White painted parts are treated with 5 stage phosphate process and finished with high reflectance baked enamel.
3. Pendant, surface, wall mount
4. Integral junction box with conduit fittings.

E. Driver and LED modules are accessible

F. Diffusers and Globes:

1. Fixed lens.
2. General distribution
3. Clear acrylic lens
4. Lineal ribbed impact modified acrylic

1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. Built to UL 1598 and 2108 standards
2. Certified to UL 924 standards with battery pack or DTS
3. Wet location label standards
4. UL sanitation certified to NSF standards
5. ingress protection IP65 and IP67 standard
6. DLC listed

2.8 RECESSED LINEAR [F2A]

A. Columbia LCAT

B. Nominal Operating Voltage: 277 V ac.

C. LED Module:

1. Minimum 3,492 lm.
2. Minimum allowable efficacy of [90] 129 lm/W.
3. CRI of minimum 90. CCT of 3500 K.
4. Rated lamp life of 60,000 hours to L80.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.

7. Lens Thickness: At least 11-inch (2.5-mm) minimum unless otherwise indicated.

D. Housings:
1. Die-formed code gauge cold-rolled steel
2. powder coat white finish
3. Integral junction box with conduit fittings.

E. An access plate is furnished with each luminaire for fast wiring access without the necessity to open the fixture or wireway. Removable lens for easy access to LED module and electrical components

F. Diffusers and Globes:

1. Fixed lens.
2. General distribution
3. Acrylic Lens
4. High transmission extruded acrylic enclosed lens features linear prisms with custom frost for high efficacy without pixelation

1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. IC rated
2. Built to UL1568 and 2108 standards
3. Certified to UL 924 standards with battery pack or DTS
4. Damp location standard
5. Adheres to LM79, LM80, and TM21 industry standard
6. DLC listed

2.9 STRIP LIGHT [F9A, F9B, F9C]

A. Columbia MPS

B. Nominal Operating Voltage: 277 V ac.

C. LED Module:

1. Minimum 5831 lm.
2. Minimum allowable efficacy of [80] 115 lm/W.
3. CRI of minimum 80. CCT of 3500 K.
4. Rated lamp life of 60,000 hours to L80.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.
7. Replaceable lens

8. Lens Thickness: At least 11-inch (2.5-mm) minimum unless otherwise indicated.

D. Housings:
1. code gauge steel

2. White painted parts are treated with 5 stage phosphate bonding process and finished with high reflectance baked enamel
3. Surface mount, wall mount, pendant mount
4. Integral junction box with conduit fittings.

E. Removable lens

F. Diffusers and Globes:

1. Fixed lens.
2. Wide distribution
3. frosted acrylic lens
4. frosted acrylic lens

1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. UL 1598 and 2108 standards
2. Damp location
3. Certified to UL 924 standards with battery pack or DTS
4. Adheres to LM79, LM80, and TM21 standard

2.10 SURFACE MOUNT LINEAR [F5C]

A. Columbia ESL

B. Nominal Operating Voltage: 277 V ac.

C. LED:

1. Minimum 4,556 lm.
2. Minimum allowable efficacy of [80] 114 lm/W.
3. CRI of minimum 80. CCT of 3500 K.
4. Rated lamp life of 60,000 hours to L80.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.
7. Replaceable lens

8. Lens Thickness: At least 11-inch (2.5-mm) minimum unless otherwise indicated.

D. Housings:
1. code gauge steel
2. power coat white

3. Surface mount, wall mount
4. Integral junction box with conduit fittings.

E. Removable lens

F. Diffusers and Globes:

1. Fixed lens.
2. Wide distribution
3. Prismatic acrylic lens
4. 100% Prismatic acrylic lens

1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. UL 1598 and 2108 standards
2. Damp location
3. Certified to UL 924 standards with battery pack or DTS
4. Adheres to LM79, LM80, and TM21 standard
5. DLC listed

2.11 SURFACE MOUNT LINEAR [F11]

A. FINELITE HP4-WW-D

B. Nominal Operating Voltage: 277 V ac.

C. LED:

1. Minimum 4,282 lm.
2. Minimum allowable efficacy of [80] 102 lm/W.
3. CRI of minimum 80. CCT of 3500 K.
4. Rated lamp life of 200,000 hours to L70.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.
7. Replaceable lens

8. Lens Thickness: At least 11-inch (2.5-mm) minimum unless otherwise indicated.

D. Housings:
1. precision cut 6061-T6 extruded aluminum body
2. power coat white

3. wall mount
4. Integral junction box with conduit fittings.

E. Removable lens

F. Diffusers and Globes:

1. Fixed flush lens.
2. General distribution
3. Frosted snap in acrylic diffuser
4. Acrylic lens 73% transmissive, 99% diffusion

1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. UL 1598 and 2108 standards
2. Damp location

2.12 SURFACE MOUNT NON-LINEAR [F7]

A. HUBBELL OUTDOOR LNC2

B. Nominal Operating Voltage: 277 V ac.

C. LED:

1. Minimum 3,991 lm.
2. Minimum allowable efficacy of [70] 114.6 lm/W.
3. CRI of minimum 70. CCT of 3500 K.
4. Rated lamp life of 60,000 hours to L70.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.

D. Housings:
1. Die cast aluminum housing
2. power coat white
3. J-box mounted or conduit feed on all 4 sides
4. Integral junction box with conduit fittings.

E. Accessible junction box

F. Diffusers and Globes:

1. Type 3 distribution

G. Standards:

1. UL 1598 for wet location
2. IP 65 assembly
3. DLC listed

2.13 SURFACE MOUNT NON-LINEAR [F8]

A. SPECGRADE LED OUTDOOR TARUS-C

B. Nominal Operating Voltage: 277 V ac.

C. LED:

1. Minimum 2332 lm.
2. Minimum allowable efficacy of [70] 143 lm/W.
3. CRI of minimum 70. CCT of 3500 K.
4. Rated lamp life of 85,000 hours to L70.
5. Internal driver.
6. Frosted glass lens with removable aluminum guard
1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Die Cast Aluminum
2. Polyester power coat
3. Integral junction box with conduit fittings.

E. Tempered Glass lens

F. Diffusers and Globes:

1. Fluorosilicone Rubber
3. Stainless Steel

G. Standards:

1. UL 1598 Listed
2. UL 1598A Marine Listed
3. UL 844 Listed
   Class I, Division 2, Groups A, B, C, D
   Class II, Division 2, Group F, G
   Class III
4. NEMA 4X

2.14 SURFACE MOUNT LINEAR [F12]

A. COLUMBIA HP-2

B. Nominal Operating Voltage: 277 V ac.

C. LED:

1. Minimum 3,195 lm.
2. Minimum allowable efficacy of [80] 194.8 lm/W.
3. CRI of minimum 80. CCT of 3500 K.
4. Rated lamp life of 100,000 hours to L80.
5. Dimmable from 10 percent to zero percent of maximum light output.
6. Internal driver.
7. Replaceable lens

8. Lens Thickness: At least 11-inch (2.5-mm) minimum unless otherwise indicated.

D. Housings:
1. precision cut 6061-T6 extruded aluminum body
2. power coat white
3. wall mount
4. Integral junction box with conduit fittings.

E. Replaceable LED Drive

F. Diffusers and Globes:

5. Fixed flush lens.
6. General distribution
7. Frosted snap in acrylic diffuser
8. Acrylic lens 73% transmissive, 99% diffusion

1. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. UL 1598 and 2108, 924 standards
2. Damp location
3. RLD, RLA

3. EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaires:

1. **Attached to structural members in walls.**
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:

1. Ceiling Mount:

   a. **Two** 5/32-inch- (4-mm-) diameter aircraft cable supports **adjustable to** [**10 feet (3 m) in length**].

2. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and **rod** for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within **12** months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to **two** visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 265213 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with integral or remote emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support, arranged by designation.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, coordinated with each other, using input from installers of the items involved:

B. Product Certificates: For each type of luminaire.

C. Seismic Qualification Data: Certificates, for luminaires, accessories, and components, from manufacturer.

D. Sample Warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7-10.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for recessed luminaires.

F. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body.

1. Emergency Connection: Operate one LED lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding 3300 feet.

4. Test Push-Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Battery: Sealed, maintenance-free, nickel-cadmium type.
6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

G. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.

1. Emergency Connection: Operate one LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Nightlight Connection: Operate lamp in a remote fixture continuously.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type.
6. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the emergency power unit manufacturer, whichever is less.
7. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
8. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.3 EXIT SIGNS

A. Internally Lighted Signs:

1. Manufacturers: Subject to compliance with requirements.

   See Light Fixture Schedule for available manufacturers offering products that may be incorporated into the work

2. Operating at nominal voltage of 120 V ac.
3. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.

3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Clear, UV-stabilized acrylic.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing.
2. Clear anodized powder coat painted finish.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.

3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of fixture weight.

E. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20-gage backing plate attached to wall structural members.
2. Do not attach fixtures directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of fixture oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.

H. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

SECTION 265619 - LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of the following:

1. Luminaire.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.6 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7-10.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598 and listed for wet location.

D. Lamp base complying with ANSI C81.61.

E. CRI of minimum 80. CCT of 3000 K.

F. L70 lamp life of 50,000 hours.

G. Nominal Operating Voltage: 277 V ac.

H. Lamp Rating: Lamp marked for outdoor use.

I. Source Limitations:

1. Obtain luminaires from single source from a single manufacturer.
2. For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:

1. Manufacturers: Subject to compliance with requirements.

   See Light Fixture Schedule for available manufacturers offering products that may be incorporated into the work.

2. Luminaire Shape: Square.
3. Mounting: Pole with extruded-aluminum rectangular arm, 6 inches in length.
4. Luminaire-Mounting Height: Twenty (20) feet.
5. Distribution: Type III.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

    a. Color: Dark bronze.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color:

        1) As selected from manufacturer's standard catalog of colors.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install drivers in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls or attached to a minimum 1/8 inch backing plate attached to wall structural members.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.2 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 24 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

    a. IES LM-5.
    b. IES LM-50.
    c. IES LM-52.
    d. IES LM-64.
    e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

END OF SECTION

27 02 00 General Requirements

27 02 01 Summary

A. The Scope of Work covered by this document is to furnish and install the Structured Cabling Systems and Pathways and Spaces systems for Indiana University Health Medical Center Campus Central Utility Plant. This work will provide for the structured cabling system (SCS) for all Voice and Data systems. Work on this project will commence after the award of the bid to a successful bidder.

B. Contact Information:

1. Owner's Representative: **(INSERT INFORMATION)**
Name, company, address
Phone: XXX-XXX-XXXX (C), XXX-XXX-XXXX (W)
E-Mail:

2. Structured Cabling Designer:

Name: Mark Lehman

Company: Applied Engineering Services
Address: 5975 Castle Creek PKWY N DR, Ste 300
Indianapolis, IN 46250
Phone: 317-810-4141
E-Mail: mlehman@applied-e-s.com

C. Telecommunications system shall include the following systems:

1. Structured Cabling System (SCS) For Telecommunications Systems
2. Pathways for Telecommunications Systems
3. Grounding and Bonding System (GBS) For Telecommunications Systems
4. Firestopping for Telecommunications Systems
5. Communications UTG horizontal cabling systems
   - Building-Edge cabling systems
   - Extended-Edge cabling systems
   - Cable pathways and cable management systems
   - UTG Testing
   - Labeling and administration

Qualified Contractors

1. Qualified contractors must have a current Bicsi certified RCDD on staff to perform work on this campus.
2. Qualified contractors must be a Commscope certified Business Partner and capable of offering a 25 year warranty for all

Commscope product installed on this campus.

3. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.
4. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
5. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
TIA/EIA-568-C.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards
ISO/IEC 11801 - Generic Cabling for Customer Premises CENELEC EN-50173 - Generic Cabling Systems

27 02 05 Additional Requirements

B. **Integration**: Responsibility for overall telecommunications system integration and coordination of work among trades, subcontractors, and suppliers shall rest with Contractor named in construction contract issued by Owner’s Representative.

Work covered by this division of specifications shall be coordinated with related work indicated on drawings or specified elsewhere under project specifications. Work related to telecommunications system shall be performed under direct supervision of telecommunications system installer in a manner approved by product manufacturer.

C. **Coordination of work:** Contractor shall be responsible for coordination of work among project specification divisions and contractor/subcontractors involved in this project. This coordination of Work Includes following instructions provided the Construction Manager or General Contractor if project is managed by such. See section 27 02 10 for additional information.

D. **General compliance requirements:** Provide a complete and operable system in compliance with project drawings, specifications, referenced standards, applicable building codes, and Authority Having Jurisdiction (AHJ) requirements. Scope of this contract includes planning, design, materials, equipment, labor, configuration, programming, testing, startup and commissioning services, and documentation costs for complete and operable system that meets all requirements indicated on drawings or contained in specifications. Comply with all contract documents, specifications, drawings, manufacturer's instructions, and Owner and AHJ requirements. In case of conflict among applicable
documents or standards, contractor shall notify owner's representative in writing of apparent conflict, and then comply with most stringent requirements unless otherwise directed in writing from owner's representative. Work includes all items required for complete system whether or not identified in specification or drawings.

E. Information about general construction and architectural features and finishes shall be derived from structural and architectural drawings and specifications only.

F. Items referred to in singular number in Contract Documents shall be provided in quantities necessary to complete work.

G. Work related to telecommunications system shall be installed by an SCS manufacturers authorized or certified trained installer and supervised an SCS manufacturers authorized or certified SCS Engineer. Owner reserves the right to review and approves any personnel assigned to this project in a supervisory or managerial role.

H. SCS contractor shall have had at least 10 years of comparable experience with telecommunications projects. As part of the

proposal, SCS installer shall submit at least three (3) comparable Project reference descriptions with reference contacts. Comparable projects shall equal or exceed size and complexity of work on drawings.

I. Color coding in Telecommunications Rooms

Station Cable Color Code:

Cable or System	Color of Cable	Color of Jack
Data Network	White	Ivory - Hospital White - Clinic
Fire Alarm	Red	NA
Nurse Call	Green	NA
Patient Monitoring	Orange	Orange
Fetal Monitoring	Orange	Green
BMDI (Network)	White	Black
Telemetry	Pink & Blue	NA
Mobile Access	White	NA
Door Security	Yellow	NA
Wireless Access Point	Lilac	Lilac
Infant Security	Slate	NA

J. **Complete and usable work:** Refer to and comply with requirements in section 27 02 67 outlined below.

K. All Division 27 work shall be performed in strict accordance with all applicable laws, ordinances, codes of local, state and federal governments, or other authorities having jurisdiction (AHJ). A UTG-Certified Integrator is required to verify all requirements.

L. The Utility Grade Infrastructure program consists of UTG-Certified Integrator shall complete the Division 27 installation and testing of the structured cabling system. UTG-Certified Integrators are specifically trained on installation techniques and best practices used to maintain cabling system performance that exceeds industry standards. The installing contractor shall have completed standards based product and installation training from the selected manufacturer, as well as completed UTG-Certified Integrator training.

M. All members of the installation team must be certified by the UTG manufacturer as having completed all necessary factory training.

N. One Designer/Project Manager shall be trained and certified in UTG.

O. UTG-Certified Integrators shall be able to field certify the installation to convey a manufacturer supported 25-year Application Assurance Warranty by meeting the UTG Framework.

P. UTG-Certified Integrator shall have a BICSI RCDD on staff (or retained) that will be responsible for design and installation oversight. The RCDD shall be made available to support the field technicians during the installation as required.

Q. Architectural and Engineering specifications may have additional conditions or requirements that affect the work defined by Division 27 in these specifications. The UTG-Certified Integrator shall be responsible for the coordination of all conditions and other trade requirements that may impact schedule, scope of work, work progress, or other factors that may affect the overall ability for the UTG-Certified Integrator to execute the requirements of Division 27.

R. All material installed shall be new in manufacturer packaging. Refurbished and or used equipment and components is not permitted for use. UTG-Certified Integrator shall be required to remove and replace such material at no added cost.

27 02 10 Related Documents and Drawings

A. **General:** The project drawings and general conditions of Contract shall apply to this section.

B. **Coordination:** Coordinate with work specified in other sections and divisions of specifications.

C. **Reference:** Codes and standards as referenced in Section 27 02 20 may define additional specifications or requirements not specifically called out within this division. However, contractor shall adhere to most stringent requirements as defined herein, or as defined by reference within section 27 02 20.

D. Architectural and Engineering specifications may have additional conditions or requirements that affect the work defined by this division of specifications. Contractor shall be responsible for the coordination of all conditions and other trade requirements that may impact schedule, scope of work, work progress, or other factors that may affect the overall ability for contractor to execute the requirements of this division of specifications.

27 02 20 Codes and Standards

A. General: All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation and workmanship shall comply with the latest editions of the requirements of the Authority Having Jurisdiction (AHJ), National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the Contractor shall satisfy the most stringent requirements.

B. Other sections of this document contain References to Codes and Standards that are applicable to the section.

27 02 20.20 Codes

A. Insulated Cable Engineers Association (ICEA)

ANSI/ICEA S-84-608-2002, Telecommunications Cable, Filled Polyolefin Insulated Copper Conductor, 2002.

ANSI/ICEA S-90-661-2002, Category 5e Individually Unshielded Twisted-Pair Indoor Cable for Use in General Purpose and LAN Communication Wiring Systems, 2002.

ICEA S-102-700-2004, ICEA Standard for Category 6 Individually Unshielded Twisted-Pair Indoor Cables for Use in LAN Communication Wiring Systems Technical Requirements, 2004

B. National Fire Protection

Association (NFPA) NFPA 70,

National Electrical Code®

(NEC®), 2008

NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, 2004

NFPA 72, National Fire Alarm Code®, 2007

NFPA 75, Standard for the Protection of Electronic Computer/Data Processing Equipment, 2009

NFPA 76, Recommended Practice for the Fire Protection of Telecommunications Facilities, 2009

NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems, 2009

NFPA 101, Life Safety Code®, 2006

NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials, 2006

NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces, 2007

NFPA 780, Standard for the Installation of Lightning

Protection Systems, 2004 NFPA 5000™, Building Construction

and Safety Code, 2006

27 02 20.40 Reference Standards

A. Telecommunications Industry

Association (TIA) ANSI X3T9.5,

Requirements for UTP at 100

Mbps

TIA TSB-125, Guidelines for Maintaining Optical Fiber Polarity Through Reverse- Pair Positioning, 2001

TIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems (2004)

TIA-526-7, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant – OFSTP-7

T-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant – SFSTP-14

TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises, 2009

TIA-568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements, 2009

TIA-568-C.2, Commercial Building Telecommunications Cabling Standard—Part 2: Balanced Twisted Pair Cabling Components, 2008

TIA-568-C.3, Optical Fiber Cabling Components Standard, 2008

TIA-569-B, Commercial Building Standards for Telecommunications Pathways and Spaces, 2004

TIA-569-B-1, Commercial Building Standard for Telecommunications Pathways and Space – Addendum 1 – Temperature and Humidity Requirements for Telecommunications Spaces, 2009

ANSI/TIA-598-C, Optical Fiber Cable Color Coding, 2005

ANSI/TIA-604.2-A, FOCIS 2—Fiber Optic Connector Intermateablility Standard, 2003

TIA-606, Administration Standard for Commercial Telecommunications Infrastructures, 2008

ANSI J-STD-607-A, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications, 2002

ANSI/TIA-758-A, Customer-owned Outside Plant Telecommunications Infrastructure Standard, 2005

ANSI/TIA-854, A Full Duplex Ethernet Specification for 1000 Mb/s (1000BASE-TX) Operating over Category 6 Balanced Twisted-Pair Cabling, 2001

TIA-862, Building Automation Systems Cabling for Commercial Buildings, 2002

TIA-942, Telecommunications Infrastructure Standard for Data Centers, 2005

ANSI/NECA/BICSI 568-2006, Standard for Installing Telecommunications Systems, 2006

Category TSB-155, Guidelines for the Assessment and Mitigation of Installed 6 Cabling to Support 10GBASE-T, 2007

B. Other Reference Materials

ANSI/NECA/GICSI-568-2006, Standard, Installing Commercial Building Telecommunications Cabling

BICSI Outside Plant Design Reference Manual (COOSP), current edition.

BICSI Electronic Safety and Security Reference Manual (ESSDRM), current edition

BICSI Information Transport Systems Installation Methods Manual (ITSIM), current edition

BICSI Network Design Reference Manual (NDRM), current edition

BICSI Telecommunications Distribution Methods Manual (TDMM), current edition

BICSI Wireless Design Reference Manual (WDRM),

current edition Institute of Electrical and

Electronic Engineers (IEEE)

National Electrical Manufacturers Association (NEMA)

Underwriters Laboratories (UL) Cable Certification and Follow Up Program

27 02 25 Abbreviations, Acronyms and Definitions

27 02 25.20 Abbreviations and Acronyms

ACD	Automatic Call Distribution
AFF	Above Finished Floor
AWG	American Wire Gauge
BICSI	Building Industry Consulting Services International
CAT5	Category 5 Copper Cable
CAT5e	Category 5e Copper Cable
CAT6	Category 6 Copper Cable
CAT6A	Category 6A Copper Cable
CDDI	Copper Distributed Data Interface
CMP	Communications Multipurpose Plenum: cable rating
CMR	Communications Multipurpose Riser: cable rating
EIA	Electronic Industries Association
ELFEXT	Equal-Level Far-End Crosstalk
FEXT	Far End Crosstalk
Gbps	Gigabits per second
HVAC	Heating, Ventilation, and Air Conditioning
IDF	Intermediate Distribution Frame - Termination frames, relay racks, and cable management
IEEE	The Institute of Electrical and Electronics Engineers
IM	Information Management
ISDN	Integrated Services Digital Network
LAN	Local Area Network
Mbps	Megabits per second
MDF	Main Distribution Frame, consisting of carrier entrance rooms and head-end
MMF	Multi-mode fiber optics, 50 or 62.5 micron laser optimized core
MUTOA	Multi-User Telecommunications Outlet Assembly
NEXT	Near End Cross Talk
NRTL	Nationally Recognized Testing Laboratories
OSHA	Occupational Safety and Health Act

PBX-	Private Branch Exchange: telephone switch
PDS	Premises Distribution Systems (See SCS.)
PoE	Power over Ethernet (IEEE 802.3af)
POP	Point of Presence
PSACR	Power Sum Attenuation-to-Crosstalk Ratio
PSAFEXT	Power Sum Alien Far-End Crosstalk
PSAELFEXT	Power Sum Alien Equal Level Far-End Crosstalk
PSANEXT	Power Sum Alien Near-End Crosstalk
PSELFEXT	Power Sum Equal Level Far-End Crosstalk
PSNEXT	Power Sum Near-End Crosstalk
SCC	Security Command Center
SCS	Structured Cabling System, or Structure Connectivity System; a complete cabling system
SFF	Small Form Factor
SMF	Single-mode fiber optics, 8.3 micron core
TC	Telecommunications Closet
TE	Telecommunications Enclosure
TEF	Telecommunications Entrance Facility
TIA	Telecommunications Industry Association
TR	Telecommunications Room
TO	Telecommunications Outlet
UPS	Uninterruptible Power Supply
UTP	Unshielded Twisted Pair
VoIP	Voice over Internet Protocol
WAO	Work Area Outlet
WAN	Wide Area Network

27 02 25.40 Definitions

Access Floor - A floor system that has removable floor panels.

Building Backbone Cabling – Cabling used to connect Floor Distributors (FD) or other local collection points to the Building Distributor (BD). Building backbone cabling typically carries aggregate traffic and, as such, impacts multiple network devices and users. Building backbone cabling may include either fiber optic or copper cabling or both.

Building Distributor (BD) – Termination point from which all building backbone cabling emanates and interconnection point for the network backbone. Commonly referred to as BDF in Americas, Main Comms Room in EMEA and Communication Room, IT Lab or IT Room in AsiaPac. Referred to as BD in international and European industry standards and Intermediate Cross-connect (IC) in American industry standards. There is one BD for each building and it feeds all FD's in the same
building. The BD should be located so that all FD's served are within 300 cable meters (984 cable feet). All BD's are linked to the

Campus Backbone Cabling – Cabling used to connect Building Distributors (BD) or other key network segments to the Campus Distributor (CD). With rare exceptions, campus backbone cabling carries aggregate traffic and typically impacts entire buildings worth of network devices and users and, as such, link redundancy with diverse routing is highly recommended. Campus backbone cabling almost exclusively consists of fiber optic cabling. Copper cabling may be used in short-distance (< 90m) applications. In such cases, lightning protection will usually be required by code.

Campus Distributor (CD) – Termination point from which all campus backbone cabling emanates and highest-level interconnection point for the network backbone. Commonly referred to as NOC in Americas and Main Comms Room in EMEA. Referred to as CD in international and European industry standards and Main Cross- connect (MC) in American industry standards. On smaller campuses, there is one CD for the campus. On larger campuses there might be several CD's with each CD
serving several buildings. Besides linking to each of the BD's it serves, the CD is also the network interconnection point for data center links and links to service providers.

Category 5e (Cat 5e) / Class D – A category/class of transmission performance that specifies electrical properties up to 155.5 MHz. Capable of supporting copper-based, four-pair Gigabit Ethernet (IEEE 802.3ab 1000BASE-T) applications. Category 5e is defined in TIA/EIA 568B.2 standard. Class D is defined in the ISO 11801 standard.

Category 6 (Cat 6) / Class E – A category/class of transmission performance that specifies electrical properties up to 250 MHz. Refer to the TIA/EIA 568B family of standards for more information on Category 6 and ISO/IEC 11801 for more information on Class E requirements. Also refer to CENELEC EN50173.

Category 6A (Cat 6) / Class E_A– A category/class of transmission performance that specifies electrical properties up to 500 MHz and capable of supporting data applications operating at 10Gbps. Refer to the TIA/EIA 568B family of standards for more information on Category 6 and ISO/IEC 11801 for more information on Class EA requirements.

Certification – The testing and documentation of the transmission performance (e.g., Category 5e / Class D) of a permanent link or channel, based on sweep frequency (where applicable) testing of numerous parameters with results compared to a range of acceptable values. This project requires 100% certification (with documentation) of all permanent link cabling at the time of installation.
Channel certification is optional and is the responsibility of the group using the channel.

Channel – The entire physical pathway between active equipment ports, inclusive of all patch cords, patch panels, jacks and cabling segments.

Class C – A category of transmission performance, defined in ISO and EN standards, that specifies electrical properties up to 16 MHz (equivalent to EIA

Conduit - A raceway of circular cross-section.

Entrance Facility (EF) – Termination point of service provider cables that have entered the building and location of service demarcation point (MPOE) and interconnection point to the network. Commonly referred to as Telco Room in Americas, POP Room in EMEA and Building Entrance in AsiaPac. Referred to as Building Entrance Facility in international and European industry standards and Entrance Facility (EF) in American industry standards. The EF is linked to the CD, where present, or to the BD.

Floor Distributor (FD) – Termination point for horizontal cabling and interconnection point for network access. Commonly referred to as IDF in Americas and AsiaPac and as Sub Comms Room in EMEA. Referred to as Floor Distributor (FD) in international and European industry standards and Horizontal Cross-connect (HC) - FD quantities and locations are determined by building size and geometry so that all points served are within 90 cable meters (295 cable feet) of an FD. The FD feeds all
Telecommunications Outlets (TO's) in its service zone. All FD's

in a building are linked to the building's Building Distributor (BD) via backbone cabling.

Horizontal Cabling – Cabling used to connect individual work area outlets to local Floor Distributors (FD) or other collection points. Unlike backbone cabling, horizontal cabling does not typically carry aggregate traffic and, as such, impacts only single network devices or users. In buildings, horizontal cabling almost exclusively consists of copper cabling. Fiber optic cabling may be used where situations dictate but, unlike horizontal copper cabling, horizontal fiber optic cabling is not installed in advance as default building facilities. At this writing, horizontal copper cabling in many networks is capable of supporting Gigabit (1Gb/s) Ethernet applications as well as other applications of similar bandwidth.

Permanent Link – A stationary cabling segment, consisting of the permanently installed cable and the permanently affixed jack at both ends (typically at the outlet faceplate and closet patch panel, or on a patch panel on both ends). The concept is based on the assumption that, while patch cords might be disconnected or moved over time, the permanent cable and jacks will not be disturbed and the electrical characteristics of the permanent link will remain unaltered.

Plenum -A space within the building designed for the movement of environmental air; i.e., a space above a suspended ceiling or below an access floor.

Raceway - Any channel designed for holding wires or cables; i.e. conduit, electrical metal tubing, busways, wireways, ventilated flexible cableway.

Spine – also called a backbone, the main communications cables in an IDF.

UTG10 – Utility Grade Infrastructure Rating Characterized as a 10-Year and beyond Technology Life Cycle.

UTG20 – Utility Grade Infrastructure Rating Characterized as a 20-Year and beyond Technology Life Cycle.

UTG Cable Certification – The testing and documentation of the transmission performance of a permanent link or channel, based on sweep frequency testing of numerous parameters with results compared to a range of acceptable values. This project requires 100% UTG certification of all permanent link cabling at the time of installation.

27 02 30 Project Drawings

A. **General Drawing Specifications:** Detail and elevation drawings shall be D size (24" x 36") with a minimum scale of 1/4" = 1'0" or larger. MDF, IDF and other enlarged detail floor plan drawings shall be D size (24" x 36") with a minimum scale of 1/4" = 1'0" or larger. Building composite floor plan drawings shall be D size (24" x 36") with a minimum scale of 1/8" = 1' 0".

B. **Building composite floor plans:** Provide building floor plans showing outlet locations and jack configuration, types of jacks, run distance for each jack cable, and cable routing/locations. Identify TO's that, according to location and available pathway systems, require cable length greater than allowed by standards. Recommend alternatives for Owners Representative's consideration.

C. **Telecommunications space plans/elevations:** Include enlarged floor plans of TRs indicating layout of equipment and devices, including receptacles and grounding provisions. Submit detailed plan views and elevations of telecommunications spaces showing racks, termination blocks, and cable paths.

D. **Logical Drawings:** Provide logical riser or schematic drawings for all systems. Include schematic symbol key.

27 02 50 Substitutions

A. **Substitution requests:** Substitution requests will be considered only if submitted to Owner's Representative not less than 7 working days prior to project bid date. Acceptance or rejection of proposed substitution is at Owner's Representatives sole discretion. No exceptions. Requests for substitutions shall be considered *not approved* unless approval is issued in writing by Owner's Representative.

B. **Rejection:** For equipment, cabling, wiring, materials, and all other products indicated or specified as *no substitutions* or *no alternates*, Owner does not expect nor desire requests for substitutions and alternate products other than those specified. Owner reserves right for Owner's Representative to reject
proposed substitution requests and submissions of alternates without review or justification.

27 02 63 Pre-Installation Meeting

A. **General:** After award, convene a pre-installation meeting at least 14 calendar days prior to commencing SCS and related work. The meeting must be scheduled at least 14 days in

advance. Require attendance of parties directly affecting work of this section, including other trades and utilities if necessary. Review conditions of operations, procedures, and coordination with related work.

B. **Agenda:** Comply with following agenda specifications:

1. Tour, inspect, and discuss building conditions relating to telecommunications system cabling and equipment, coordination with Telephone Utility Company, Owner's telecommunications system

   requirements, and coordination with existing conditions and other work in contract.

2. Review exact location of each item within building construction, casework, and fixtures, and their requirements.

3. Review required submittals, both completed and yet to be completed.

4. Review drawings and specifications.

5. Review proposed equipment, cabling, and related work.

6. Review and finalize construction schedule related to telecommunications system and verify availability of materials, personnel, equipment, and facilities needed to make progress and avoid delays.

7. Review required inspections and testing.

8. Review cable routing and support provisions.

27 02 65 Warranty

27 02 65.10 Contractors Warranty

A. **General requirements:** Comply with additional requirements in contract general requirements and extended warranties required in other specification sections. Refer to all other 27xxx sections for specific additional warranty requirements that exceed or are in addition to those of this section.

B. **Contractor warranty:** Provide all services, materials, and equipment necessary for successful operation of entire telecommunications system and SCS system for a period of one year after system acceptance. Scope of warranty includes all equipment, devices, wiring, accessories, software, hardware, installation, programming, and configuration required to maintain a complete and operable system. Provide manufacturer's published recommended preventative maintenance procedures during warranty period. This shall apply to all items except those specifically excluded, or items wherein a longer period of service and warranty is specified or indicated. All warranties shall be effective for one year, minimum, from date Certificate of Final

Acceptance is issued. Use of systems provided under this section for temporary services and facilities shall not constitute final acceptance of work nor beneficial use by Owner and shall not institute warranty period. The warranty shall cover repair or replacement of defective materials, equipment, workmanship, and installation that may be incurred during this period. Warranty work is to be done promptly and to Owner's satisfaction. In addition, warranty shall cover correction of damage caused in making necessary repairs and replacements under warranty. Additional warranty responsibilities are:

1. Obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's designated name. Replace material and equipment that require excessive service during guarantee period as determined by Owner.
2. Provide 2-business day service beginning on date of Substantial Completion and lasting until termination of warranty period. Service shall be at no cost to Owner. Service can be provided by installing contractor or by a separate service organization. Choice of service organization shall be subject to Owner's approval. Submit name and a phone number that will be answered on a 24-hour basis each day of week, for duration of service.
3. Submit copies of equipment and material warranties to Owner before final acceptance.
4. At end of warranty period, transfer manufacturers' equipment and material warranties still in force to Owner.
5. If warranty work problems cannot be corrected immediately to Owner's satisfaction, advise Owner in writing, describing efforts to correct situation, and provide analysis of cause for problem. If necessary to resolve problem, provide at no cost services of manufacturer's engineering and technical staff at site in a timely manner to analyze warranty issues, and develop recommendations for correction, for review and approval by Owner.

C. **Owner's rights:** This section shall not be interpreted to limit Owner's rights under applicable codes and under this Contract.

D. **Pathways Material and Installation warranty:** Provide all services, materials, and equipment necessary to warrant the installation and performance of all pathway materials for a period of one year after beneficial use. Scope of warranty includes all equipment, devices, installation, and other work required to maintain a complete and operable system. Provide manufacturers published recommended preventative maintenance procedures during warranty period.

E. **Grounding and Bonding Material and Installation warranty:** Provide all services, materials, and equipment necessary for successful operation of GBS for a period of one year after beneficial use. Scope of warranty includes all equipment, devices, installation, and other work required to maintain a complete and operable system. Provide manufacturers published recommended preventative maintenance

procedures during warranty period.

F. **Firestopping Material and Installation warranty:** Provide all services, materials, and equipment necessary to warrant the performance of all Firestopping material for a period of one year after beneficial use, or longer if required by the local AHJ. Scope of warranty includes all equipment, devices, installation, and other work required to maintain a complete and operable system. Provide manufacturers published recommended preventative maintenance procedures during warranty period.

27 02 65.20 SCS Manufacturers Extended Warranty

A. SCS Systems will be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified vendor. Manufacturer shall administer a follow on program through the Vendor to provide support and service to the purchaser. The first part is an assurance program, which provides that the certified system will support the applications for which it is designed, during the 20-year warranty of the certified system.

B. The second portion of the certification is a 20-year warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).

C. In the event that the certified system ceases to support the certified application(s), whether at the time of cutover, during normal use or when upgrading, the manufacturer and vendor shall commit to promptly implement corrective action.

D. Documentation proving the cabling system's compliance to the End-to-End Link Performance recommendations, as listed in ANSITIA/EIA-568-B shall be provided by the Vendor prior to the structured cabling system being installed.

E. The cabling system must conform to the current issue of industry standard ANSI/TIA/EIA-568. All performance requirements of this document must be followed. As well, workmanship and installation methods used shall be equal toor better than that found in the BICSI (Building Industry Consulting Service International) ITSIM manual.

F. Purchaser demands strict adherence to the performance specifications listed in ANSI/TIA/EIA-568-B series standards.

G. Manufacturer shall maintain ISO Quality Control registration for the facilities that manufacturer the product used in this cabling system.

27 02 65.30 UTG Manufacturers Extended Warranty

A. All UTG20 cabling solutions have a manufacturer supported 25-year Applications Assurance Warranty when installed by a UTG-Certified contractor. When installed per TIA or ISO/IEC standards and field tested to the UTG test limits with a Fluke Versiv DSX Cable Analyzer™, the Utility Grade Infrastructure will operate all application(s) with beyond standards performance as outlined in the UTG Framework.
B. The manufacturer of the UTG solution shall provide an application assurance warranty, which provides that the certified system will support the applications for which it was designed, during the 25-year warranty period of the system.
C. The UTG-Certified Integrator supported by the manufacturer shall provide a 25-year warranty on all products within the UTG system (cords, telecommunications outlets, connectors, cables, cross-connects, patch panels, etc.).
D. Workmanship will be fully guaranteed by the UTG-Certified Integrator. Defects which may occur as the result of faulty workmanship within 1 year after installation and acceptance by owner will be corrected by the UTG-Certified Integrator at no additional cost to the owner.

27 02 67 Completeness of Work

A. **Complete and usable work:** The contractor is responsible for providing complete and usable work according to contract documents. All materials and equipment shall be provided with all accessories and additional work required for field conditions, as well as additional work and accessories required for complete, usable, and fully functional construction and systems, even if not explicitly specified or indicated. Telecommunications system in this Contract shall be provided as complete and operable systems in full compliance with requirements on drawings and specification requirements. Drawings are diagrammatic and specifications are performance-based, and Contractor shall provide all work required to comply with drawings and specifications, even if not explicitly indicated or specified. Contractor shall be responsible for coordinating installation of electrical systems with all field conditions and work of other trades. Minimum clearances and work required for compliance with NFPA 70, *National Electrical Code®* (*NEC®*), and manufacturer's instructions shall be provided. Comply with additional requirements indicated for access and clearances. Contractor shall verify all field conditions and dimensions that affect selection and provision of materials and equipment, and shall provide any disassembly, reassembly, relocation,

demolition, cutting, and patching required to provide work specified or indicated, including relocation and reinstallation of existing wiring and equipment. Contractor shall protect from damage resulting from Contractor's operations existing facility, equipment, and wiring. Extra charges for completion and contract time extension will not be allowed because of field conditions or additional work required for complete and usable construction and systems. Comply with additional requirements indicated for access and clearances.

B. **Drawings and specifications form complementary requirements;** provide work specified and not shown, and work shown and not specified as though explicitly required by both. Except where explicitly modified by a specific notation to contrary, it shall be understood that indication or description of any item, in drawings or specifications or both, carries with it instruction to furnish and install item, provided complete.

C. **Terms:** As used in this specification, *provide* means *furnish* and *install*. *Furnish* means "to purchase and deliver to project site complete with every necessary appurtenance and support," and *install* means "to unload at delivery point at site and perform every operation necessary to establish secure mounting and correct operation at proper location in project."

D. **Authority approvals:** Give notices, file plans, obtain permits and licenses, pay fees, and obtain necessary approvals from authorities that have jurisdiction as required to perform work according to all legal requirements and with Specifications, Drawings, Addenda and Change Orders, all of which are part of Contract Documents.

E. **Supplementary items:** Provide supplementary or miscellaneous items, appurtenances, devices, and materials necessary for a sound, secure and complete installation. Examine project drawings and other Sections of specifications for requirements that affect work of this section. Completely coordinate work of this section with work of other Sections and provide a complete and fully functional installation. Refer to all other drawings and other specifications sections that indicate types of construction in which work shall be installed and work of other sections with which work of this section must be coordinated

F. **Quantities:** Items referred to in singular number in Contract Documents shall be provided in quantities necessary to complete work.

27 02 67.10 Quality Assurance

A. The UTG-Certified Integrator installing the UTG system shall be certified by the designated UTG manufacturer in proper installation practices to adhere to the warranty.
B. Installing UTG-Certified Integrator shall use a Fluke Versiv DSX Cable Analyzer™. The Fluke Versiv DSX Cable Analyzer™ shall include copper UTG test limits for UTG20 which include: Extended performance at 100m and extended distances of 150m and 185m as applicable.
C. The test results shall be compatible with latest version of Fluke LinkWare™ software.
D. Installed UTG copper cabling infrastructure, pathways and distribution facilities will adhere to manufacturer's instructions, contract drawings and applicable codes, standards and regulations with the exception of extended distances.
E. All UTG rated copper cabling systems shall be UL Verified containing a 7-digit verification code representing a specific manufacturer's solution rated for UTG20.
F. Substitutions or like equivalents will not be accepted. UTG copper cabling is verified by UL and contain verification numbers to guarantee the solutions performance. A UTG solution is tested beyond industry standards and therefore not interchangeable with like or similar components.

27 02 70 Project Conditions

A. **Field verification:** Carefully verify location, use and status of all material, equipment, and utilities that are specified, indicated, or deemed necessary for removal. Verify that all materials, equipment, and utilities to be removed are completely inactive and will not be required or in use after completion of project. Replace with equivalent any material, equipment and utilities that were removed by Contractor that are required to be left in place.

B. **Existing utilities:** As applicable, do not interrupt utilities serving facilities occupied by Owner or others unless permitted under following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify owner in writing at least 14 days in advance of proposed utility interruptions. Do not proceed with utility interruptions without Owner's written permission.
2. Equipment installation:
   a. Determine suitable path for moving unit substation into place; consider Project conditions.

b. Verify clearance requirements and locate equipment to meet installation tolerances.
c. Revise locations and elevations from those indicated to those required to suit Project.

27 02 73 Delivery Storage and Handling

A. **General:** Contractor shall be responsible for the deliveries, storing and handling of all materials relative to the SCS systems, including materials supplied by others that are part of the SCS installation contract. Material shall be stored and protected according to manufacturer's instructions. Contractor shall be responsible for the security of all material during installation. For all material provided by contractor, or delivered to contractor on site, contractor assumes full responsibility and liability for any material shortages, damage, or loss due to storage and handling methods.

27 02 75 Permits and Inspections

A. **General:** All telecommunications systems shall meet or exceed the latest requirements of all national, state, county, municipal, and other authorities exercising jurisdiction over the telecommunications systems and the Project.

B. Contractor shall obtain and pay for all licenses, permits, and inspection fees required by local agencies and/or other agencies having jurisdiction.

C. Contractor agrees to furnish any additional labor or material required to comply with all local and other agencies having jurisdiction at no additional cost.

D. Contractor shall obtain certificates of inspection and approval from all authorities having jurisdiction, and forward copies of same to Owner's Representative prior to request for Project acceptance inspections, final completion inspections, substantial completion inspections, and acceptance testing/demonstrations.

E. All required permits and inspection certificates shall be made available at the completion of the telecommunications system installation and commissioning.

F. Any portion of the telecommunications work which is not subject to the requirements of an electric code published by a specific AHJ shall be governed by the National Electrical Code and other applicable sections of the *National Fire Code*, as published by the National Fire Protection Association (NFPA).

G. Installation procedures, methods and conditions shall comply

with the latest requirements of the Federal Occupational Safety and Health Administration (OSHA).

27 02 77 Examination

A. **General:** Prior to submitting a proposal, Contractor shall examine site, review Project drawings and specifications, and determine exact extent of work required. Contractor shall include in their proposals all materials, labor, and equipment required to complete required work indicated. Work that is necessary to obtain complete and usable Project as specified herein shall be included in Contractor's proposal, even if not indicated or specified.

B. **Bidders' questions:** Should bidders have questions as to intent of drawings and specifications, quality of materials to be used, and work to be performed, questions shall be submitted in writing to Owner's Representative in manner dictated by Owner's Representative. All answers and clarifications to drawings and specifications will be issued in writing.

C. Extra payment will not be allowed for claims for due to unfamiliarity with work to be performed by other trades, existing conditions at job site, local or state laws and codes, and alterations due to field conditions.

27 02 79 Additional Costs

A. **General:** Project acceptance inspections, final completion inspections, substantial completion inspections, and acceptance testing/demonstrations shall be conducted after verification of system operation and completeness by Contractor.

B. **Inspections and testing:** For Project acceptance inspections, final completion inspections, substantial completion inspections, and/or testing/demonstrations that require more than one site visit by Owner's Representative or Architect/Engineer to verify Project compliance for same material or equipment, Owner reserves right to obtain compensation from Contractor to defray cost of additional site visits that result from Project construction or testing deficiencies/incompleteness, incorrect information, or non-compliance withProject provisions. Owner's Representative will notify Contractor of hourly rates and travel expenses for additional site visits, and will issue an invoice to Contractor for additional site visits. Payment of additional site visit costs by Contractor is required within 30 days of invoicing. Owner reserves right to deduct additional costs defined herein that are

indicated on past due invoices from Project amount due Contractor.

C. **Exclusions:** Contractor shall not be eligible for extensions of Project schedule or additional charges resulting from additional site visits that result from Project construction or testing deficiencies/incompleteness, incorrect information, or non-compliance with Project provisions.

END of SECTION

27 04 00 Execution

27 04 01 General Requirements

A. General: Sequence, coordinate, and integrate various elements of telecommunications system, materials, and equipment. Comply with following requirements as a minimum.

C. Coordinate systems, equipment, and materials installation with other building components.

D. Verify all dimensions by field measurements.

E. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for wiring, cabling, and equipment installations.

F. Coordinate installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

G. Sequence, coordinate, and integrate installations of materials and equipment for efficient flow of Work. Give particular attention to large equipment requiring positioning prior to closing in building.

H. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide maximum headroom and access for service and maintenance as possible.

I. Coordinate connection of materials, equipment, and systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

J. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by Contract Documents, recognizing that portions of Work are shown only in diagrammatic form. In case of conflict among individual system requirements, request direction in writing from Owner's Representative.

K. Install systems, materials, and equipment level and plumb, parallel, and perpendicular to other building systems and components, where installed in both exposed and un-exposed spaces.

L. Install cabling, wiring, and equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

M. Provide access panel or doors where units are concealed behind finished surfaces.

N. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

O. Comply with all requirements and work indicated on drawings.

P. Avoid interference with structure and with work or other trades, preserving adequate headroom and clearing doors and passageways to satisfaction of Owner and according to code requirements.

Q. Install equipment and cabling/wiring to properly distribute equipment loads on building structural members provided for equipment support under other Sections. Roof-mounted equipment shall be installed and supported on structural steel or roof curbs as appropriate.

R. Provide suspended platforms, strap hangers, brackets, shelves, stands or legs as necessary for floor, wall and ceiling mounting of equipment as required.

S. Provide steel supports and hardware for proper installation of hangers, anchors, guides, and other support hardware.

T. Obtain and analyze catalog data, weights, and other pertinent data required for proper coordination of equipment support provisions and installation.

U. Structural steel and hardware shall conform to ASTM standard specifications. Use of steel and hardware shall conform to requirements of AISC Code of Practice: Section Five.

V. Verify site conditions and dimensions of equipment to ensure access for proper installation of equipment without disassembly that would void warranty.

27 04 10 Equipment Installation

A. General: Install equipment according to manufacturer's written instructions. Install equipment level and plumb. Install wiring and cabling between equipment and all related devices.

B. Mounting: If neither the Owner's Instructions nor the individual section call out the required hardware mounting, use the following.

1. For equipment at walls, bolt units to wall or mount on structural steel channel strut bolted to wall.
2. For equipment not at walls, provide freestanding racks fabricated of structural steel members and slotted structural steel channel strut.
3. Use feet consisting of 0.25 inch thick steel plates, 6 square inch, bolted to floor.
4. Use feet for welded attachment of vertical posts not over 3 feet on center.
5. Connect posts with horizontal U channel steel strut and bolt control equipment to channels.

C. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

D. Connections: Tighten wiring connectors, terminals, bus joints, and mountings, to include lugs, screws, and bolts according to equipment manufacturer's published torque tightening values for equipment connectors. In absence of published connection or terminal torque values, comply with torque values

specified in UL 486A and UL 486B.

E. Installation and configuration shall conform to the requirements of the current revision of TIA Standards, BICSI ICT, National Electrical Code, applicable local codes, and to the manufacturer's installation instructions.

27 04 33 Penetrations and Sleeves

A. General: Coordinate work with other sections. SCS Installation Contractor shall be responsible for the provision of cabling sleeves and conduits unless specifically provided by the Electrical Contractor. SCS Installation Contractor shall coordinate with Electrical Contractor to determine exact requirements.

B. When required, set sleeves in forms before concrete is poured. Provide core drilling as necessary if walls are poured or otherwise constructed without sleeves and wall penetration is required. Do not penetrate structural members. Provide sleeves and packing materials at all penetrations of foundations, walls, slabs (except on-grade), partitions, and floors. Sleeves shall meet requirements of pertinent specifications. Lay out penetration and sleeve openings in advance, to permit provision in work. Set sleeves and conduit in forms before concrete is poured. Provide remedial work where sleeves and conduits are omitted or improperly placed.

C. Sleeve fill: Sleeves that penetrate outside walls, basement slabs, footings, and beams shall be waterproof.

1. Fill slots, sleeves and other openings in floors or walls if not used.
2. Fill spaces in openings after installation of conduit or cable.
3. Fill for floor penetrations shall prevent passage of water, smoke, fire, and fumes.
4. Fill shall be fire resistant in fire floors and walls, and shall prevent passage of air, smoke, and fumes. See section 27 05 32 - Firestopping for Telecommunications Systems.
5. Sleeves through floors shall be watertight and shall extend 2 inches above floor surface.
6. Where raceways passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling, and wall finishes.

D. Conduit sleeves:

1. Annular space between conduit and sleeve shall be at least 1/4 inch.
2. Sleeves shall not be provided for slabs-on-grade unless specified or indicated otherwise.
3. For sleeves through rated fire walls and smoke partitions, comply with requirements for firestopping. See section 27 05 32 - Firestopping for Telecommunications Systems.

E. Supports: Do not support piping risers or conduit on sleeves.

F. Future use: Identify unused sleeves and slots for future installation.

27 04 36 Core Drilling

A. General: Core drilling shall be avoided where possible. Where core drilling is unavoidable, locate all required openings prior to coring.

B. Coordinate openings with other trades and utilities, and prevent damage to structural reinforcement.

C. Thoroughly investigate existing conditions in vicinity of required opening prior to coring.

D. Set sleeves prior to installation of structure for passage of pipes, conduit, ducts, etc. Protect all areas from damage.

27 04 39 Cleaning

A. Contractor is responsible for cleanup of debris on a daily basis. Cost of cleanup is the responsibility of the Contractor.

B. During progress of work, remove equipment and unused material. Put building and premises in neat and clean condition. Perform cleaning and washing required to provide acceptable appearance and operation of equipment to satisfaction of Owner's Representative.

C. After completion of Project, clean exterior surface of all equipment, including concrete residue, dirt, and paint residue. Final cleaning shall be performed prior to Project acceptance by Owner's Representative.

27 04 60 Startup and Operational Testing

A. General: Owner maintains right to have access to entire project site to prepare facility for occupancy and operation. Completion of startup and field testing shall be accomplished as a prerequisite for substantial completion. Operate and maintain systems and equipment until final acceptance by Owner. All guarantees and warranties shall not begin until final acceptance of systems and equipment by Owner. Acceptance requires, at a minimum, complete systems startup and testing.

B. UTG field testing is currently performed using a Fluke Versiv DSX Cable Analyzer™. This tester supports the current UTG framework (version 2.0 and future versions) test limits.

27 04 70 Special Responsibilities and Information

A. Coordination of information: Cooperate and coordinate with work of other sections in executing work of this section. Perform work such that progress of entire project, including work of other sections, shall not be interfered with or delayed. Provide information as requested on items furnished under this section, which shall be installed under other sections. Obtain detailed installation information from manufacturers of equipment provided under this section.

B. Information gathering: Obtain final rough-in dimensions or other information as needed for complete installation of items furnished under other sections or by Owner. Keep fully informed as to shape, size and position of openings required for material or equipment to be provided under this and other sections. Give full

information so that openings required by work of this section may be coordinated with other work and other openings and may be provided for in advance. In case of failure to provide sufficient information in proper time, provide cutting and patching or have same done, at no expense to Owner.

C. Housekeeping pads: Provide information as requested as to sizes, number and locations of concrete housekeeping pads necessary for floor mounted equipment

D. Maintenance of equipment and systems: Maintain equipment and systems until Final Acceptance. Ensure adequate protection of equipment and material during delivery, storage, installation and shutdown and during delays pending final test of systems and equipment because of seasonal conditions.

E. Use of premises: Use of premises shall be restricted as directed by Owner's Representative and as required below:

1. **Cleaning and rubbish removal:** Remove and dispose of dirt and debris, and keep premises clean. During progress of work, remove equipment and unused material. Put building and premises in neat and clean condition, and do cleaning and washing required to provide acceptable appearance and operation of equipment, to satisfaction of Owner's Representative.
2. **Rubbish Removal:** Provide for the removal from the site of all spoils, debris, boxes, packaging, crates, and trash generated from the work.
3. **Storage:** Store materials maintaining an orderly, clean appearance. If stored on site in open or unprotected areas, all equipment and material shall be kept off ground by means of pallets or racks, and covered with tarpaulins.

F. Protection of fireproofing:

1. Clips, hangers, clamps, supports and other attachments to surfaces to be fireproofed shall be installed, if possible, prior to start of spray fire proofing work.
2. Conduits and other items that would interfere with proper application of fireproofing shall be installed after completion of spray fire proofing work.
3. Patching and repairing of fireproofing due to cutting or damaging to fireproofing during course of work specified under this section shall be performed by installer of fireproofing and paid for by section responsible for damage and shall not constitute grounds for an extra to Owner.

G. Temporary utilities: Refer to contract general requirements regarding requirements.

H. Movement of materials: Unload materials and equipment delivered to site. Pay costs for rigging, hoisting, lowering and moving equipment on and around site, in building or on roof.

I. UTG Infrastructure requires a unique identifier to separate it from standards based installations. UTG expands upon standards and requires special recognition to distinguish extended distances from standard distances.

J. UTG Labeling and Administration shall follow all TIA-606 standards. In addition to TIA standards the UTG-Certified integrator shall use a printed diamond ◊

symbol prefix followed by a notation displaying total distance 100M, 150M and 185M to uniquely identify the following:

1. Work Area Outlets
2. Telecommunication Outlets
3. Patch Panels
4. Modular Plug Terminated Links (MPTLs)
5. Consolidation Points (CPs)
6. Cables
7. Patch Cords

K. UTG backbone fiber optics, Extended-Edge, Building-Edge and Connected-Ceiling applications shall follow TIA-606 standards. In addition to TIA standards the UTG-Certified integrator shall use a printed diamond ◊ symbol prefix followed by a notation displaying Tier 1 critical or Tier 2 essential infrastructure to uniquely identify it as part of the complete UTG solution. Uniquely identify the following:

1. Fiber Optic Cables
2. Fiber Optic Patch Panels
3. Fiber Optic Enclosures
4. Fiber Optic Patch Bays
5. Fiber Optic Splices

L. The UTG-Certified Integrator shall ensure that the required UTG markers and identification is implemented when manual or electronic record keeping is requested. All electronic record keeping including but not limited to RFID, QR coding and bar coding shall employ unique identifiers for recording UTG infrastructure.

27 04 80 Division of Work

A. General: Division of work responsibility matrix at the end of this section is for Contractor's reference to clarify roles of various manufacturers, installers, subcontractors, and trades involved in telecommunications system Project.

B. Contractor holding contract with Owner is responsible for coordinating work of all subcontractors to provide a complete and usable Project complying with contract provisions of Project documents.

C. Failure to coordinate work by subcontractors and suppliers will not be considered justification for additional compensation or extension of schedule.

Division of work responsibility chart

Spec. section	System	Contractors Gen	Elec	Mec	Telecom	Remarks
25 xx xx	Building Automation System (BAS)	1	C	C	C	BAS low voltage cabling by Division 23 uses telcom cable tray.

21 xx xx	Fire Detection And Alarm System (FDAS)	1	C	C	C	Completely separate cabling system and raceways by Division 26
26 xx xx	Electrical wiring (line voltage)	1	2,W	C	C	Completely separate cabling system and raceways by Division 26
26 xx xx	Poke-through fittings and floor boxes	1	2, E	C	C	Telcom to provide data jacks and A-V connectors
26 xx xx	Cable tray	1	2, E	C	C	Comply with Section 27 05 28
26 xx xx	Electrical raceways	1	2, E	C	C	Comply with Section 27 05 28
27 02 00	General requirements for telecommunications system	2	C	C	1	
27 10 00	Structured Cabling System (SCS) for telecommunications systems		C	C	1, E, W	
27 05 28	Pathways for telecommunications systems	1	2, P	C	1	
27 05 26	Grounding and Bonding System (GBS) for telecommunications systems	1	2, G	C	1	
27 05 32	Firestopping for telecommunications systems		2, FP	C	1, FC	

1 = primary contractual responsibility
2 = secondary responsibility
3 = tertiary responsibility
C = coordination of work responsibility
E = provision of specified equipment and devices
W = provision of specified system wiring/cabling
P = provision of specified system pathways/conduits
S = provision of specified system spaces
FP = provision of specified firestopping for pathways
FC = provision of specified firestopping for cabling

END of SECTION

27 05 00 Common Work Results for Communications

27 05 26 Grounding and Bonding for Communications Systems

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of work called for in the Contract Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for the equipment and cable installations in communications equipment rooms (Telecommunications Closets).

B. Included in this section are the minimum composition requirements and installation methods for the following:

1. Grounding Electrode System
2. Busbars
3. Bonding accessories

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Material and work specified herein shall comply with the applicable requirements of the current revision of the following:

ANSI/TIA – 568 Commercial Building Telecommunications Cabling Standard
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual

1.4. Submittals

A. Provide product data for the following:

Manufacturers cut sheets, specifications, and installation instructions for all products (submit with bid).

2. PRODUCTS

2.1. Grounding Electrode System

A. Grounding Electrode System

1. When required the Grounding Electrode System shall meet the following
   a. Active grounding system constantly replenishing moisture into the soil
   b. Provide low resistance to ground
   c. Provide season to season stability
   d. Be maintenance-free for 30 years
   e. Contain no hazardous materials or chemicals
2. Approved Manufacturers:

2.2. Wall-mount Busbars

A. Telecommunications Main Grounding Busbar (TMGB)

1. Telecommunications Main Grounding Busbar (TMGB) shall be constructed of .25” (6.4 mm) thick solid copper bar.
2. The busbar shall be 4” (100 mm) high and 20” (510 mm) long and shall have 30 attachment points (two rows of 15 each) for two-hole grounding lugs.
3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 27 lugs with 5/8” (15.8 mm) hole centers and 3 lugs with 1” (25.4) mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4” (100 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Approved Products
   a. CPI 40153-020 20” Wall-mount TMGB Busbar

2.3. Bonding Accessories

A. Two Mounting Hole Ground Terminal Block

1. Ground terminal block shall be made of electroplated tin aluminum extrusion.
2. Ground terminal block shall accept conductors ranging from #14 AWG through 2/0.
3. The conductors shall be held in place by two stainless steel set screws.
4. Ground terminal block shall have two 1/4” (6.4 mm) holes spaced on 5/8” (15.8 mm) centers to allow secure two-bolt attachment to the rack or cabinet.
5. Ground terminal block shall be UL Listed as a wire connector.
6. Approved Product
   a. CPI 40167-001 2 Hole Ground Terminal Block

B. Compression Lugs

1. Compression lugs shall be manufactured from electroplated tinned copper.
2. Compression lugs shall have two holes spaced on 5/8” (15.8 mm) or 1” (25.4 mm) centers, as stated below, to allow secure two bolt connections to

busbars.

3. Compression lugs shall be sized to fit a specific size conductor, sizes #6 to 4/0, as stated below.
4. Compression lugs shall be UL Listed as wire connectors.
5. Approved Product
   a. CPI (Size appropriately based on the Application)

C. Antioxidant Joint Compound

1. Oxide inhibiting joint compound for copper-to-copper, aluminum-to-aluminum or aluminum-to-copper connections.
2. Approved Product
   a. CPI 40166-801 Aluminum to copper joint compound.

D. C-Type, Compression Taps

1. Compression taps shall be manufactured from copper alloy.
2. Compression taps shall be C-shaped connectors that wrap around two conductors forming an irreversible splice around the conductors; installation requires a hydraulic crimping tool
3. Compression taps shall be sized to fit specific size conductors, sizes #2 AWG to 4/0, as stated below.
4. Compression taps shall be UL Listed.
5. Approved Products
   a. CPI (Size appropriately based on the Application)

E. Pedestal Clamp With Grounding Connector

1. Pedestal clamp shall be made from electroplated tinned copper or bronze. Installation hardware will be stainless steel.
2. Pedestal clamps shall be sized to fit a specific size conductor, size #6 and/or 2/0, as stated below.
3. Pedestal clamp installation hardware shall be sized to attach to round and/or square raised access floor pedestals that are 1-1/8” to 1-3/4” in diameter, as stated below.
4. Pedestal clamp shall provide straight (in-line) or cross (intersection) support for up to two conductors.
5. Pedestal clamp shall be UL Listed as grounding and bonding equipment.
6. Approved Product
   a. CPI 40169-001 Pedestal Clamp, Cross connector (2) #6 per side.

F. Pipe Clamp With Grounding Connector

1. Pipe clamp shall be made from electroplated tinned bronze. Installation hardware will be stainless steel.
2. Pipe clamp shall be sized to fit up to two conductors ranging in size from #6 to 250 MCM; conductors must be the same size.
3. Pipe clamp installation hardware shall be sized to attach to pipes, sizes 1” to 6” (.75” to 6.63” in diameter), as stated below.
4. Pipe clamp shall be UL Listed as grounding and bonding equipment.
5. Approved Products
   a. CPI 40170-001 Pipe Clamp .5 - .75”
   b. CPI 40170-002 Pipe Clamp 1.0 - 1.25”

c. CPI 40170-003 Pipe Clamp 1.5 – 2.0”
d. CPI 40170-004 Pipe Clamp 2.5 – 3.0”
e. CPI 40170-005 Pipe Clamp 3.5 – 4.0”

G. Equipment Ground Jumper Kit

1. Kit includes one 24”L insulated ground jumper with a straight two hole compression lug on one end and an L-shaped two hole compression lug on the other end, two plated installation screws, an abrasive pad and a .5 once tube of antioxidant joint compound.
2. Ground conductor is an insulated green/yellow stripe #6 AWG wire
3. Lugs are made from electroplated tinned copper and have two mounting holes spaces .5” to .625” apart that accept 1/4” screws.
4. Jumper will be made with UL Listed components
5. Approved Products
   a. CPI 40159-010 Equipment Ground jumper kit.

3. EXECUTION

3.1 Installation

A. Outdoor grounding and bonding connections.

1. All outdoor grounding and bonding (earthing) connections shall be accomplished using exothermic welding.

B. Wall-Mount Busbars

1. Attach busbars to the wall with appropriate hardware according to the manufacturer’s installation instructions.
2. Conductor connections to the TMGB or TGB shall be made with two-hole bolt-on compression lugs sized to fit the busbar and the conductors.
3. Each lug shall be attached with stainless steel hardware after preparing the bond according to manufacturer recommendations and treating the bonding surface on the busbar with antioxidant to help prevent corrosion at the bond.
4. The wall-mount busbar shall be bonded to ground as part of the overall Telecommunications Bonding and Grounding System.

C. Rack-Mount Busbars and Ground Bars

1. When a rack or cabinet supports active equipment or any type of shielded cable or cable termination device requiring a ground connection, add a rack-mount horizontal or vertical busbar or ground bar to the rack or cabinet. The rack-mount busbar or ground bar provides multiple bonding points on the rack for rack and rack-mount equipment.
2. Attach rack-mount busbars and ground bars to racks or cabinets according to the manufacturer’s installation instructions.
3. Bond the rack-mount busbar or ground bar to the room’s TMGB or TGB with appropriately sized hardware and conductor.

D. Ground Terminal Block

1. Every rack and cabinet shall be bonded to the TMGB or TGB.
2. Minimum bonding connection to racks and cabinets shall be made with a

rack-mount two-hole ground terminal block sized to fit the conductor and rack and installed according to manufacturer recommendations.
3. Remove paint between rack/cabinet and terminal block, clean surface and use antioxidant between the rack and the terminal block to help prevent corrosion at the bond.

E. Pedestal Clamp

1. At minimum, bond every sixth raised access floor pedestal with a minimum #6 AWG conductor to the TMGB or TGB using a pedestal clamp sized to fit the pedestal and the conductor and installed according to the manufacturer's recommendations.
2. If pedestal clamps are used to construct a signal reference grid, bond the signal reference grid to the TMGB or TGB and bond each rack and/or cabinet to the signal reference grid using a compression tap or similar non-reversible bonding component sized to fit both conductors.
3. Remove paint between the pedestal and pedestal clamp, clean surface and use antioxidant between the pedestal and the clamp to help prevent corrosion at the bond.
4. Remove insulation from conductors where wires attach to the pedestal clamp.

F. Pipe Clamp

1. Bond metal pipes located inside the data center computer room with a minimum #6 AWG conductor to the TMGB or TGB using a pipe clamp sized to fit the pipe and the conductor and installed according to the manufacturer's recommendations.
2. Remove paint between the pipe and pipe clamp, clean surface and use antioxidant between the pipe and the clamp to help prevent corrosion at the bond.
3. Remove insulation from conductors where wires attach to the pipe clamp.

G. Equipment Ground Jumper Kit

1. Bond equipment to a vertical rack-mount busbar or groundbar using ground jumper according to the manufacturer's recommendations.
2. Clean the surface and use antioxidant between the compression lugs on the jumper and the rack-mount busbar or groundbar to help prevent corrosion at the bond.

END OF SECTION

27 05 28 Pathways for Communications Systems

1. GENERAL

1.1. Scope of Work

A. Install empty raceway system, including underfloor and overhead distribution system, fish wire, terminal cabinets, outlet boxes, floor boxes, pull boxes, cover plates, conduit, sleeves and caps, cable troughs, service poles, miscellaneous and positioning material to constitute complete system, as indicated for distribution of Telecommunications wiring which includes cables for Data, Voice, Video, Audio, Security and future signal requirements.

A. The location at which all new telecommunications wiring will terminate is called a Telecom Outlet (TO). There are several styles of outlets:

1. New construction
2. Existing construction typical
3. Existing construction variations
4. Telephone (Voice) only
5. Data only

B. Furnish and install split channel raceway and outlet boxes as specified in the Drawings and as specified herein.

C. Furnish and install conduit stubs in walls and floors for cable routes.

1.2. References

ASI/NFPA 70/250 - National Electric Code – Ground and Bonding
ANSI/NFPA 70/318 – National Electric Code – Cable Trays
CANSI/NFPA 70/645 – National Electric Code – Information Technology Equipment
ANSI/NFPA 70/770 – National Electric Code – Optical Fiber Cables and Raceways
ASTM A 510 - Specifications for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel
ASTM B 633 - Specifications for Electrodepositing Coatings of Zinc on Iron and Steel, Sections SC2 and SC3
ASTM A653 - Specifications for Steel Sheet, Zinc-Coated (Galvanized) by Hot Dip Process
ASTM A123 - Specifications for Zinc (Hot Galvanized) Coatings on Iron and Steel
ANSI/TIA - 568-B Commercial Building Telecommunications Cabling Standard.
ANSI/TIA - 569-A Commercial Building Standard for Telecommunications Pathways and Spaces
ASTM – A276-06 Standard Specification for Stainless Steel Bars and Shapes
ASTM A580/A580M-06 Standard Specification for Stainless Steel Wire
NEMA VE 2-2006 Cable Tray Installation Guidelines
NEMA VE-1/CSA C22.2 No 126 1-02 Metal Cable Tray Systems
UL and cUL E209183
ANSI C80.1 Rigid Steel Conduit - Zinc Coated
ANSI C80.4 Fittings for Rigid Metal Conduit
BICSI Electronic Safety and Security Reference Manual (ESSDRM), current edition
BICSI Information Transport Systems Installation Methods Manual (ITSIM),

current edition
BICSI Network Design Reference Manual (NDRM), current edition
BICSI Telecommunications Distribution Methods Manual (TDMM), current edition
BICSI Wireless Design Reference Manual (WDRM), current edition

1.3. Quality Assurance:

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Assure that the "as installed" system is correctly and completely documented including engineering drawings, manuals, and operational procedures in such a manner as to support maintenance and future expansion of the system.

D. Material and work specified herein shall comply with the applicable requirements of the current revision of the following:

ANSI/TIA – 568 Commercial Building Telecommunications Cabling Standard
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
NFPA 70B, “Recommended Practice for Electrical Equipment Maintenance” pertaining to cable tray systems.

1.4. Submittals

A. Product Data: For features, ratings, and performance of each component specified.

B. Submit manufacturer’s instructions for storage, handling, protection, examination, preparation, operation, and installation of products. Include application conditions or limitations of use stipulated by any product testing agency. Submit for the following:

1. Wall Boxes
2. Raceway
3. Conduit
4. Conduit Bushings

C. Shop Drawings:

1. Component List: List manufacturer, part number, and quantity of each component.
2. Include dimensioned plan and elevation views of equipment rooms, labeling each individual component. Show raceway assemblies, method of field assembly, workspace requirements, and access for cable connections.

1.5. Delivery Storage and Handling:

A. Delivery: Deliver materials to site in manufacturer's original un-opened containers and packaging, with labels clearly indication manufacturer and material.

B. Storage: Store materials in a dry area indoors, protected from damage and in accordance with manufacturer's instructions.

C. Handling: Protect materials and finishes during handling and installation to prevent damage.

2. PRODUCTS

2.1. Telecom Outlets (TO)

A. Note: The listed material, manufacturers, and part numbers are not exhaustive. This is meant to be used as a guideline for all installations. Any deviations from these must be presented to IU Health Telecommunications Department for approval!

B. New construction TO consists of one (1) 4-11/16" square by 2-1/8" deep flush mounted box. Each outlet box shall have an EMT conduit stubbed above the drop ceiling or extended into the hallway cabletray. Conduits size is as follows:

1. For Outlets with 2-4 cables, use a 1.25" EMT conduit.
2. For all other sizes, calculate fill ratio at 40% for proper sized conduit

C. The intent of the installation of the TOs which consist of the raceway is as follows:

1. Where ceilings are accessible, the raceway and entrance end fitting shall extend above the ceiling and the conduits installed above the ceiling in the room to the nearest hallway distribution system.
2. Where ceilings are partially accessible, or if the Drawings and/or Specifications indicate installation of access panels, the raceway shall extend above the ceiling and the conduits installed above the ceiling in the room to the nearest hallway distribution system.
3. Where ceilings are inaccessible or no ceilings exist, the raceway shall extend up as close to the ceiling as practical to allow installation of conduits as high as possible to the nearest hallway distribution system.

2.2. Horizontal Distribution Systems

A. Conduit System (Renovations only, where conduit exists)

1. Provide conduits secured to wall above corridor ceilings as shown on the Drawings or as specified herein for installation of telecommunications cables. Any exposed conduit
2. Corridor conduits shall be 4" EMT, furnished in 10 foot lengths wherever possible, with no sharp edges, reamed as necessary, evenly supported at two locations per 10 foot section spacing. Conduits shall be sized and quantified to account for handling cables in all TO conduits at 40% fill back to the IDF and/or MDF rooms. Verify size prior to installation. Bushings and/or connectors on ends of EMT are required.
3. All conduits shall be installed stacked and attached to walls unless conditions exist which prohibit this type of installation. When this condition exists, mount conduits side-by-side supported with 3/8” rod attached to building structure utilizing unistrut channel to form a trapeze. Double nut the top and bottom at the unistrut. Utilize conduit clamp to secure conduits to unistrut.
4. Provide measured pull line in each conduit rated at 1200 lbs. minimum. Increments must be in 12” steps.
5. Grounding of conduits is not required per NEC #250-33, Exception No. 2. shall be painted except conduit above suspended ceilings or in mechanical, electrical or telecommunication rooms. Color to match that of surface installed upon or as directed by Owner’s Representative. Coordinate with other trades prior to painting.
6. Provide restorable fire stops inside and around conduits as recommended by UL1479 or ASTM E814 for all conduits penetrating fire-rated construction. Fire rated construction to be verified with AHJ. See Section 27 05 32 for more firestopping information.

B. Telecommunication Room Cable Tray System

1. IDF cable tray shall completely wrap all walls within the room. Cable tray shall extend over all equipment frames.
2. Cable tray shall be a minimum width of 2” high x 12” wide. Cable tray may be sized upwards if fill ratio requirements need to be met based on cable quantities.
3. Manufacturer of tubular ladder type cable tray in telecommunication rooms shall be: Commscope or CPI.
4. Cable tray shall be 12 inch cable runway.
5. Rectangular steel tubing cross members welded at 12-inch intervals. Finish in black enamel. CommScope, Part Number CR-SLR-10L-12W or equivalent.
    a. 12-inch Wall Angle Assembly Kit – CommScope

Part Number CR6- 12WRSK or equivalent.

b. 3-inch Channel Rack–To-Runway Mounting Plate - CommScope Part Number CRR2RRMK or equivalent.
c. End Closing Tube - CommScope Part Number CRPECK or equivalent.
d. Corner Clamp - CommScope Part Number CRTJSK or equivalent (2 required per End Closing Tube to complete assembly).

C. All open pathway/trays shall be installed a minimum of six (6) inches away from any light fixture or other source of EMI (Electromagnetic Interference).

D. All pathways shall be grounded per NEC Article 250.

E. Provide external grounding strap at expansion joints, sleeves and crossover and at other locations where pathway/tray continuity is interrupted.

F. Support all pathways from building construction. Do not support pathways from ductwork, piping, or equipment hangers.

G. Install cable tray level and straight unless noted on the construction drawings

H. Manufacturer of Cable Tray shall be: CommScope or CPI

1. Universal Cable Runway (Ladder Rack 9’11” L x 18” W x 1.5”H 10250-718
2. Universal Cable Runway (Ladder Rack 9’11” L x 12” W x 1.5”H 10250-712
3. Triangular Wall Support Bracket for 12” W – 18” W Cable Runway 11312-718
4. Cable Runway Wall Angle Support kit for 18” W Runway 11421-718
5. Junction Splice Kit for Cable Runway 1.5” x 0.375” 11302-701
6. Ground Bar 19” Rack 10610-019
7. 10” TGB Grounding Busbar kit w/hardware, 2”W x 0.25”H x 10”L 13622-010

2.3. Station Conduits

Station conduit is defined as conduit that originates at the TO and rises within the walls or is exposed from a raceway and extends up into the drop ceiling or over to the hallway distribution system.

A. Provide station conduits from TOs to above the drop ceiling or extend over to the hallway distribution systems consisting of 1.25” EMT for 4 cables or less. If greater than 4 cables, please size the EMT based on a 40% fill ratio.

B. Provide an insulating press fit bushing on all telecommunications conduits including interconnecting nipples and stub to distribution system. To prevent conflicts with other cables or conduits to cable tray, the conduit shall be stubbed not less than 6" above or below conduit/cable tray center line. Where space permits, every effort shall be made to bend station conduits down such that the flow of installed cables promotes the minimum length back to the IDF and the least amount of bends in the cables. Bushings must be rated to be used in an environmental air handling space (Plenum).

C. Manufacturer of insulating bushing on all telecommunication conduits shall be:

D. Provide measured pull line in 12” increments in each empty conduit to hallway distribution system.

E. Indelibly mark station conduit at hallway distribution end with Room # that conduit serves.

F. The use of 90 degree electrical pulling elbows is prohibited.

G. Do not include more than two 90 degree bends between pulling points when installing station conduit runs. If the path of the station conduits requires more than 180 degrees of total bends, installation of an appropriate sized junction box is required. See section 2.4 for junction box requirements.

H. Place an appropriate sized junction box in each individual station conduit run that exceeds 100 feet in length.

I. The use of a third bend in a conduit is only acceptable if:

1. The total conduit run is reduced by 15%.
2. The conduit size is increased to the next trade size.
3. One of the bends is located within 12” of the cable feed end.

2.4. Junction Box Requirements For Station Conduits

A. If the station conduit route exceeds the 180 degree of total bends limitation, an appropriate sized junction box is required within a straight section of the conduit run.

B. Each station conduit run requires a separate junction box. The sharing of a junction box by multiple conduits is prohibited.

C. A junction box shall not be used in place of a bend. All junction

boxes in station conduit paths shall be installed within a straight section of the conduit run.

2.5. Service Entrance Conduits

A. Minimum of (4) 4” IMC conduits shall be installed from the nearest utility tunnel on outside of the building as shown on the Drawings. Terminate entrance conduits entering MDF rooms from below grade to extend 4" above finished floor. Location of entrance conduits shall be within 12” of room corners.

B. Terminate entrance conduits entering MDF rooms from above ceiling height to extend 4" below finished ceiling or 12” above cable tray.

C. Terminate entrance conduits entering an MDF rooms from below ceiling height to extend 4" into the room.

D. Entrance conduits shall be continuous into the building and to the MDF. Securely fasten all entrance conduits to the building to withstand any cable placing operation. Do not include more than two 90 degree bends between pulling points when installing entrance conduits.

E. On exterior wall penetrations, seal both sides of the wall around outside of conduit with hydraulic cement to prevent water from entering the building. Seal the inside of the conduit on both sides with conduit plugs, water plugs, or duct sealer to prevent water, vapors, or gases from entering the building.

2.6. Pathway Requirements For Entrance Conduits

A. If the entrance conduits exceeds the 180 degree of total bends limitation, an appropriate sized junction box, manhole, or handhole is required.

B. As-built drawings of entrance conduit path required to be submitted to Owner’s Representative before covered with soil.

2.7. Riser Conduits

Riser conduits shall only be used when noted on the Construction Documents for special applications only. Riser conduits are not required as a general rule for the riser system. However, when required:

A. Minimum of (2) 4” conduits shall be installed between the MDF room and each IDF room as shown on the Drawings.

B. Conduits entering MDF and IDF rooms shall be reamed or bushed and terminated not more than 4" from entrance wall and within 12” of room corners.

C. Conduits entering MDF and IDF rooms from below floor shall be terminated not more than 4" above finished floor.

D. Conduits for riser cables shall be continuous and separate from all other conduit or enclosed raceway systems. Do not include more than two 90 degree bends between pulling points when installing riser conduits. Where junction boxes are required, locate in accessible areas, such as above suspended ceilings in hallways.

E. Conduits shall not be less than 4" trade size and be equipped with a measured pull line at 12” increments rated at a minimum 1200 pound test.

F. Provide restorable fire stops inside and around conduits as recommended by UL1479 or ASTM E814 for all conduits penetrating fire-rated construction. Fire- rated construction to be verified with AHJ. See Section 27 05 32 for more firestopping information.

G. Provide an insulating press fit bushing on all telecommunications riser conduits. Bushings must be rated to be used in an environmental air handling space (Plenum).

1. Manufacturer of insulating bushing on all telecommunication conduits shall be Arlington or equal.

H. Riser conduits shall not be used for the distribution of horizontal cables.

2.8. Firestopping

A. In all buildings, floor/ceiling assemblies, stairs, and elevator penetrations must be sealed with a 2-hour fire stop assembly at a minimum, unless otherwise noted.

B. Contact Owner’s Representative to identify walls which are fire-rated construction. Walls must be sealed with a 2-hour fire stop assembly at a minimum.

C. Communication pathways requiring fire stopping shall utilize removable/re- usable fire stopping putties for ease of Moves, Adds, and Changes.

D. All fire stopping penetrations shall conform to the recommended practices listed in UL1479 or ASTM.

E. See Section 27 05 32 - Firestopping for Telecommunications Systems

3. EXECUTION

3.1. General Requirements

A. The intention of the telecommunications conduits is to provide a route between MDF and IDF rooms, routes from the IDFs

throughout building floors to hallways, and routes from hallway distribution systems into rooms to individual TOs for telecommunications cabling.

B. Installation of new pathways shall not interfere with existing pathways in such a way that installation of new cables within the existing pathway is made more difficult.

3.2. Examination

A. Examine areas to receive cable management system. Notify the Owner's Representative of conditions that would adversely affect the installation or subsequent utilization of the system.

B. Do not proceed with installation until unsatisfactory conditions are corrected.

3.3. Installation

A. Install in accordance with recognized industry practices, to ensure that the equipment complies with requirements of the NEC, and applicable portions of NFPA 70B and NECA "Standards of Installation" pertaining to general electrical installation practice.

B. Coordinate installation with other trades.

C. Field verification is required before installation.

D. Install cable management system at locations indicated on the drawings and in accordance with manufacturer's instructions.

END OF SECTION

27 05 29 Hangers and Supports for Communications Systems

1. GENERAL

1.1. Work Includes

The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, and services to completely execute the system of non-continuous cable supports as described in this specification.

1.2. Scope of Work

This Section includes the minimum requirements for the support structures for the Communications Systems for the project as outlined in the Bid Document.

A. Non-continuous cable supports (2.3A)
B. Adjustable non-continuous cable support sling (2.3B)
C. Multi-tiered non-continuous cable support assemblies (2.3C)
D. Non-continuous cable support assemblies from tee bar (2.3D)
E. Non-continuous cable support assemblies from drop wire/ceiling (2.3E)
F. Non-continuous cable support assemblies from beam, flange (2.3F)
G. Non-continuous cable support assemblies from C & Z Purlin (2.3G)
H. Non-continuous cable support assemblies from wall, concrete, or joist (2.3H)
I. Non-continuous cable support assemblies from threaded rod (2.3I)
J. Cantilever-Mounted Option for non-continuous cable supports (2.3J)
K. Installation accessories for non-continuous cable supports (2.3K)

1.3. Submittals

A. Submit product data on non-continuous cable support devices, including attachment methods. Product data to include, but not limited to materials, finishes, approvals, load ratings, and dimensional information.

1.4. Quality Assurance

A. Non-continuous cable supports and cable support assemblies shall be listed by Underwriters Laboratories for both Canadian and US standards (cULus).
B. Non-continuous cable supports shall have the manufacturers name and part number stamped on the part for identification.
C. Manufacturer: Company specializing in manufacturing products specified in this section with a minimum of five years documented experience in the industry, and certified ISO 9000.

1.5. Coordination

Coordinate installation of hangers, supports and cables with other trades.

2. PRODUCTS

2.1. Acceptable Manufacturers

A. Note: The listed material, manufacturers, and part numbers are not exhaustive. This is meant to be used as a guideline for all installations. Any deviations from these must be presented to IU Health Telecommunications Department for

approval!

B. Subject to compliance with these specifications, non-continuous cable supports shall be as manufactured by:
   - Erico CAT48HP
   - Erico CAT64HP

2.2. References

ASTM B633 Standard Specification for Electro-deposited Coatings of Zinc on Iron and Steel
ASTM B 695-90 Standard Specification for coatings of Zinc Mechanically Deposited on Iron and Steel
ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM A109 Standard Specification for Steel, Strip, Carbon, Cold-Rolled
ASTM A167 Standard Specification for Stainless and heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A480/A480M Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
ASTM A568 Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy Hot-Rolled and Cold-Rolled
A653 G60-Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-coated (Galvannealed) by the Hot-Dip process
ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM A682 Standard Specification for Steel, Strip, High-Carbon, Cold-Rolled, Spring Quality
ASTM A879 Standard Specification for Steel Sheet, Zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface
ASTM B117 Standard Method of Salt Spray (Fog) Testing
ASTM D610 Standard test Method for Evaluating Degree of Rusting on Painted Steel Surfaces
UL 2043 - Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.
ANSI/ TIA-568 Commercial Building Telecommunications Cabling Standard, current revision level.
ANSI/ TIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces, current revision level.
NFPA 70 National Electrical Code®

2.3. Non-continuous Cable Support Systems

A. Non-continuous cable supports
   1. Non-continuous cable supports shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance cables; cULus Listed.
   2. Non-continuous cable supports shall have flared edges to prevent damage

while installing cables.

3. Non-continuous cable supports sized 1 5/16” and larger shall have a cable retainer strap to provide containment of cables within the hanger. The cable retainer strap shall be removable and reusable and be suitable for use in air handling spaces.
4. Non-continuous cable supports shall have an electro-galvanized or G60 finish and shall be rated for indoor use in non-corrosive environments.
5. Stainless Steel non-continuous cable supports are intended for indoor and outdoor use in non-corrosive environments or where only mildly corrosive conditions apply.
6. Non-continuous cable supports shall be as manufactured by:

B. Adjustable non-continuous cable support sling
   1. Constructed from steel and woven laminate; sling length can be adjusted to hold up to 425 4-pair UTP; rated for indoor use in non-corrosive environments. Rated to support Category 5e and higher cable, or optical fiber cable; cULus Listed.
   2. Adjustable non-continuous cable support sling shall have a static load limit of 100 lbs.
   3. Adjustable non-continuous cable support sling shall be suitable for use in air handling spaces.
   4. If required, assemble to manufacturer recommended specialty fasteners including beam clips, flange clips, C and Z purlin clips.
   5. Acceptable products:
C. Multi-tiered non-continuous cable support assemblies
   1. Multi-tiered non-continuous cable support assemblies shall be used where separate cabling compartments are required. Assemblies may be factory assembled or assembled from pre-packaged kits. Assemblies shall consist of a steel angled hanger bracket holding up to six non-continuous cable supports, rated for indoor use in non-corrosive environments; cULus Listed.
   2. If required, the multi-tier support bracket may be assembled to manufacturer recommended specialty fasteners including beam clamps, flange clips, C and Z purlin clips.
   3. The multi-tiered support bracket shall consist of:
D. Non-continuous cable support assemblies from tee bar
   1. Tee bar support bracket with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.
   2. Acceptable products:
E. Non-continuous cable support assemblies from drop wire/ceiling
   1. Fastener to wire/rod with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.
   2. Acceptable products:
F. Non-continuous cable support assemblies from beam, flange
   1. Fastener to beam or flange with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.
   2. Acceptable products:

G. Non-continuous cable support assemblies from C & Z Purlin
   1. Fastener to C or Z purlin with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments, cULus Listed.
   2. Acceptable products:
H. Non-continuous cable support assemblies from wall, concrete, or joist
   1. Fastener to wall, concrete, or joist with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments, cULus Listed.
   2. Acceptable products:
I. Non-continuous cable support assemblies from threaded rod
   1. Fastener to threaded rod with one non-continuous cable support, factory or jobsite assembled, rated for indoor use in non-corrosive environments, cULus Listed.
   2. The multi-tiered support bracket shall have a static load limit of 300 lbs.
   3. U-hooks and Double J-hook shall attach directly to threaded rod using standard nuts.
   4. Acceptable products:
J. Cantilever-Mounted cable supports
   1. U-hook shall be able to be assembled to a wide variety of wall mount brackets.
   2. Spacing of individual U-hooks as needed, max of 4’ to 5’ apart.
   3. U-hooks may have the optional attachment of a cable roller for ease in pulling cables.
   4. Acceptable products:
K. Installation accessories for non-continuous cable supports
   1. Cable Pulley
      a. Non-continuous cable supports may be used as an installation tool when a removable pulley assembly is included. The pulley shall be made of plastic and be without sharp edges. The pin and bail assembly must be able to be secured to the J-Hook during cable installation. The pulley must remain secured while cables are being pulled.
      b. The pin and roller assembly must be removed after cables are installed.
      c. Acceptable products:
   2. Cable Protector
      a. The protective steel tube shall fit over threaded rod and be at least 4” in length.
      b. The tube shall prevent damage to cables placed in or pulled through CAT-CMTM U-hooks. The tube shall not inhibit the pulling of cables.
      c. Acceptable products:

2.4. Finishes

A. ASTM B633 Standard Specification for Electro-deposited Coatings of Zinc on Iron and Steel
   ASTM B 695 Standard Specification for coatings of Zinc Mechanically Deposited on Iron and Steel

ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

B. Non-continuous cable supports used where only mildly corrosive conditions apply shall be stainless steel, AISI type 304.

3. EXECUTION

3.1. Installation

A. Installation and configuration shall conform to the requirements of the current revision levels of ANSI/ EIA/TIA Standards 568 & 569, NFPA 70 (National Electrical Code), applicable local codes, and to the manufacturer's installation instructions.
B. Do not exceed load ratings specified by manufacturer.
C. Adjustable non-continuous support sling shall have a static load limit of 100 lbs.
D. Follow manufacturer's recommendations for allowable fill capacity for each size non-continuous cable support.
E. Locate pathways per Telecommunications Drawings.

END of SECTION

27 05 32 Firestopping for Telecommunications Systems

1. GENERAL

1.1. Scope

A. This SECTION describes the requirements for furnishing and installing firestopping for fire-rated construction. This includes all openings in fire-rated floors, walls and other rated elements of construction, both blank (empty) and those accommodating items such as cables, conduits, pipes, ducts, etc.

B. Fireblocking for Concrete Floor or Wall Sleeved Cables.

C. Fireblocking for Gypsum Wall Sleeved Cables.

D. Fireblocking for Concrete Block Wall Sleeved Cables.

1.2. Related Documents:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 7 Specification Sections, apply to this Section.

B. Cable fill calculations must be included to show the maximum cable fill ratio for each FireStopping System and cable type.

1.3. References:

UL 1479 - Fire Tests of Through-
Penetration Firestops ASTM E-814 - Fire
Tests of Through-Penetration Fire Stops
ASTM E-119 - Fire Tests of Building
Construction and Materials ANSI/NFPA 70 –
National Electrical Code (NEC)
TIA 569 – Commercial Building Standard for
Telecommunications Pathways & Spaces
ICBO – Uniform Building Code
BOCA –
Basic/National
Building Code SSBCCI
– Standard Building
Code NFPA 101 - Life
Safety Code
UL Fire Resistance Directory – Penetration Firestops System
(XHE2) and Fill, Void or Cavity Materials.

1.4. Submittals

A. Submit manufacturer’s product literature and installation procedures for each type of Firestop material to be installed.

Literature shall indicate product characteristics, typical uses, performance and limitation criteria and test data. Submit cured samples of firestop materials.

B. Shop drawings: Show typical installation details for the methods of installation. Indicate which firestop materials will be used where and when applications requirements to meet Specific jobsite conditions.

C. Product Data: Shall be clearly marked to indicate all technical information which specifies full compliance with requirements of this section and Contract Documents, including the following:

1. Copy of UL illustration of each proposed system indicating manufacturer's approved modifications.
2. Each condition requiring penetration seals in proposed UL systems materials, anchorage, methods of installation and actual adjacent construction.

D. Applicator's Qualification Statement: Shall include a list of projects indicating required experience.

1.5. Quality Assurance

A. Firestopping systems (materials and design) shall conform to both Flame (F) ratings and Time (T) ratings as required by local building code and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire tests in a configuration that is representative of field conditions.

B. The work of this section shall be performed by a company which specializes in stalling UL Classified penetration seals required for this Project, with a minimum of five years of documented successful experience and shall be performed by skilled Workmen thoroughly experience in the necessary crafts.

C. Deliver material in the manufacturer's original, unopened containers or packages with the manufacturer's name, product identification, lot number, UL label, and mixing and installation instructions as applicable.

D. Store materials in the original, unopened containers or packages, and under conditions recommended by the manufacturer.

E. All firestop materials shall be installed prior to expiration of shelf life.

1.6. Coordination

A. Coordinate layout and installation of Firestopping System with other trades.

B. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Architect.

C. Storage and Handling: Avoid breakage, denting and scoring finishes. Damaged products will not be installed. Store devices and accessories in original cartons and in clean dry space; protect from weather and construction traffic. Wet materials will be unpacked and dried before storage.

2. PRODUCTS

2.1. Acceptable Manufacturers:

A. Note: The listed material, manufacturers, and part numbers are not exhaustive. This is meant to be used as a guideline for all installations. Any deviations from these must be presented to IU Health Telecommunications Department for approval!

B. Materials and products required for work of this section shall not contain asbestos or polychlorinated biphenyls (PCB).

C. Manufacturer and Firestopping System must be approved by the local AHJ before purchase or installation.

D. Manufacturer Shall Be: STI

- EZD22 EZ-Path Series 22 Fire-Rated Pathway
- EZD44S2 EZ-Path Series 33 Fire-Rated Pathway
- EZDR400 EZ-path retrofit device
- RFG1/RFG2 EZ-Path Grommets
- EZDG844S2 Multi-slot frame kit 8 pathways
- EZD1644S2 Multi-slot frame it for 16 pathways

2.2. General

Provide and install firestopping materials to meet applicable codes and installation requirements for each firestopping application. Products using caulking, putties, wrap strips, mortars, composite boards and/or mechanical devices shall be used as appropriate for the specific condition.

2.3. Caulking

When caulking is used, provide and install flexible caulking materials. Cured firestop materials 1/8 thick shall be able around a 1” mandrell without breaking.

2.4. Firestop

Do not use any firestop products which re-emulsify, leach active intumescent ingredients or dissolve when placed in water after curing. Product must withstand the passage of cold smoke, either as inherent property of the system or by the use of a separate product included as part of the UL system or device, and designed to perform this function.

2.5. Penetration Seals

A. General:

1. Penetration seals (firestopping material) shall be asbestos-free and capable of maintaining an effective barrier against flame, smoke and gases in compliance with requirements of ASTM E814 and UL 1479.
2. Materials shall meet and be acceptable for use by all three model building codes, Basic/National Building Code, Building Code and Standard Building Code, per National Evaluation Service, Inc. report # NER-243.
3. Materials shall meet requirements of NFPA 101 and NFPA 70.
4. Materials shall be suitable for the firestopping of penetrations made by steel, glass, plastic and insulated pipe, conduit, bus duct, noninsulated pipe and ductwork.
5. On insulated pipe, fire-rating classification must not require removal of insulation.
6. The rating of penetration seals shall not be less than the rating of the time-rated floor or wall assembly.
7. Systems shown below are examples and other equal systems may be approved or required by the AHJ.

B. 2-hour Rated Concrete Floor:

1. Penetrants: Multiple pipes.
2. Firestop as manufactured by:
3. UL System: No. 93.

C. 2-hour Rated Concrete Floor:

1. Penetrants: Maximum 30” dia. Metal pipe/conduit.
2. Firestop as manufactured by:
3. UL System: No.319

D. 1-2 –Hour Rated Gypsum Board Wall:

1. Penetrant: Metal pipe/conduit.
2. Firestop as manufactured by:
3. UL System: No. 147

E. 2-Hour Rated Gypsum Board Wall:

1. Penetrant: Metal pipe/conduit.
2. Firestop as manufactured by:
3. UL System: No. 147.

F. 3-Hour Rated Concrete Wall:

1. Penetrant: Metal duct, maximum 2’ square and maximum dimension of 30”.
2. Firestop as manufactured by:
3. UL System: No. 105.

G. Walls Below Grace:

1. Penetrants: Pipe sleeves.
2. Seal: Thunderline “Link Seal” casing seal.

3. EXECUTION

3.1. Inspection

Examine the areas and condition where Firestops are to be installed and notify the Architect of conditions detrimental to the proper and timely completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected by the contractor in a manner acceptable to the Architect.

3.2. Conditions Requiring Firestopping

A. General – Provide firestopping for conditions specified whether or not firestopping is indicated, and if indicated, whether such material is designed as insulation, safing, or otherwise.

B. At any point where a fire rated wall is penetrated with cable or conduit.

C. Penetrations

1. Penetrations include conduit, cable wire, pipe, duct or other elements which pass through one or both outer surfaces of a fire rated floor, wall or partition.
2. These requirements for penetrations shall apply whether or not sleeves have been provided, and whether or not penetrations are to be equipped with escutcheons or other trim. If penetrations are sleeved firestop any annular space between the sleeve and wall opening.

D. Provide firestopping to fill miscellaneous voids and openings in fire-rated construction as specified herein.

3.3. Installation

A. General

1. Installation of Firestops shall be performed by an applicator/installer qualified and trained by the manufacturer. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures.
2. Apply Firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, and manufacturer's recommendations.
3. Coordinate with plumbing, mechanical, electrical and other trades to assure that all pipe, conduit, cable, and other items which penetrate fire-rated construction have been permanently installed prior to installation of Firestop.

B. Field Quality Control

1. Prepare and install firestopping systems in accordance with manufacturer's printed instructions and recommendations.
2. Follow safety procedures recommended in the Material Safety Data Sheets.
3. Finish surfaces of firestopping which is to remain exposed in the completed work to a uniform and level condition.
4. All areas of work must be accessible until inspection by the applicable Code Authorities.
5. Correct unacceptable firestops and provide additional inspection to verify compliance with this specification at no additional cost.

C. Calculate the maximum cable fill ratio for each FireStopping System and cable type. Do not exceed the maximum fill ratio.

D. Prepare and install firestopping systems in accordance with manufacturer's printed instructions and recommendations.

3.4. Warranty

A. A. Comply with General Conditions, and include but not be limited to:

1. Repairs and replacement of penetration seals which fail in joint adhesion, cohesion, abrasion, resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability, or appear to deteriorate in any other manner not clearly specified in submitted manufacturer's data as an inherent quality of the material for exposure indicated.

3.5. Cleaning

A. Remove spilled and excess materials adjacent to firestopping without damaging adjacent surfaces.

B. Leave finished work in neat, clean condition with no evidence of spillovers or damage to adjacent surfaces.

END OF SECTION

27 05 33 Conduits and Backboxes for Communications Systems

1. GENERAL

1.1. Outlets

A. Each data outlet in a wall or floor shall be served by (1) 1.25" conduit up to 4 cables. Over 4 cables and a larger or multiple conduits will be needed. A single gang electrical box up to 4 cables, over 4 cables it will need to be double gang.

B. Wall mounted telephones shall be served by one 21 mm (0.75 in.) conduit and a single-gang deep device box with a single-gang mud ring. The outlet box shall be mounted at a center height of 1220 mm (48 in.) above the finished floor, unless otherwise specified on the drawing, and shall have a clearance of 305 mm (12 in.) of wall surface on all sides.

C. All outlet conduits shall be stubbed up to the open or into accessible ceiling space. Cabling will then be in J-hooks back to the MDF room on the 2nd floor.

D. All outlet conduits shall have burrs and any other abrasive elements removed and an insulating bushing shall be installed on both ends.

E. No section of conduit shall be longer than 30 m (100 ft.) between pull points.

F. No more than 180 degrees of conduit bends shall be permitted between pull points.

G. The minimum inside radius for any bend of an outlet conduit shall be six times the inside diameter of that conduit.

1.2. Conduits

A. Electric metallic tubing: Comply with UL 797. Tubing shall have hot dipped galvanized exterior, enamel-coated interior.

B. Flexible conduit shall not be used in lieu of conduit bends and offsets.

C. PVC conduit: Comply with UL 651, listed for use with 90 degrees C conductors operating at 90 degrees C.

- All conduits will be 1-1/4" in diameter with nylon bushing:
  - 1-1/4" GRC Conduit
  - 1-1/4" EMT

D. All back boxes shall be single gang up to 4 cables, over 4 cables double

gang.

1.3. Standards Compliance

A. General standards: Comply with current revision of TIA 569 as amended

1.4. Submittals

Provide product data for the following:
Manufacturers cut sheets, specifications, and installation instructions for all products (submit with bid).

1.5. Coordination

A. Coordinate installation of labels with other trades.

B. Storage and Handling: Avoid breakage, denting and scoring finishes. Damaged products will not be installed. Store materials in original cartons and in a clean dry space; protect from weather and construction traffic. Wet materials will be unpacked and dried before storage.

2. PRODUCTS

2.1. Approved Products

A. Note: The listed material, manufacturers, and part numbers are not exhaustive. This is meant to be used as a guideline for all installations. Any deviations from these must be presented to IU Health Telecommunications Department for approval!

B. Dry location device boxes: Manufacturer shall be:
Equivalent products by other manufacturers may be used where approved in writing by Owner's Representative.

C. Wet location boxes: Manufacturer shall be:
Equivalent products by other manufacturers may be used where approved in writing by Owner's Representative.

3. EXECUTION

3.1. Installation

A. Installation and configuration shall conform to the requirements of the current revision levels of ANSI/ EIA/TIA Standards 568 & 569, NFPA 70 (National
Electrical Code), applicable local codes, and to the manufacturer’s installation instructions.

D. Install conduits using techniques, practices, and methods that are consistent with Category 6 or higher requirements and that supports Category 6 or higher performance of completed and linked signal paths, end to end.

E. Follow manufacturer's recommendations for allowable fill capacity for each size non-continuous cable support.

END of SECTION

27 05 36 Cable Trays for Communications Systems

1. GENERAL

1.1. Scope

A. Continuous, rigid, welded steel or stainless steel wire mesh cable management system.

B. Cable tray systems are defined to include, but are not limited to, straight sections, supports and accessories.

1.2. Related Documents:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.3. Summary

References:

IEC 61537 (2001) – Cable Tray Systems and Cable Ladder Systems for Cable Management

NEMA VE 1-2002/CSA C22.2 No. 126.1-02 – Metal Cable Tray Systems ANSI/NFPA 70 – National Electrical Code (NEC)

TIA 569– Commercial Building Standard for Telecommunications Pathways & Spaces

ASTM A 510 - Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

ASTM A 380 – Specification for Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

ASTM B 633 – Specification for Electrodeposited Coatings of Zinc on Iron and Steel

ASTM A 123 – Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 653 - Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot- Dip Process, Structural (Physical) Quality

1.4. Submittals

A. Shop Drawings: Submit shop drawings indicating materials, finish, dimensions, accessories, layout, supports, splices, and installation details.

B. Design Calculations: Verify loading capacities for supports.

C. Field verification of all dimensions, routing, etc., is directed.

D. Factory-certified test reports of specified products, complying with IEC 61537, NEC, and NEMA VE 1/CSA C22.2 No. 126.1.

E. Submit manufacturer's certification indicating ISO 9001 quality certified.

F. Submit training procedure for certifying cable tray installers.

1.5. Quality Assurance

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Approval and Labeling: Provide cable trays and accessories specified in this Section that are approved and labeled.

The Terms "Classified" pertaining to cable trays (rather than "Listed") and "Labeled": As defined in NFPA 70, Article 100, including painted trays.

Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

C. Comply with NFPA 70, National Electrical Code, Article 392: Cable Trays; provide UL Classification and labels.

D. Comply with IEC 61537, Cable Tray Systems and Cable Ladder Systems for Cable Management.

E. Comply with NEMA VE 1/CSA C22.2 No. 126.1, Metal Cable Tray Systems, for materials, sizes, and configurations; provide cCSAus Certificate and labels.

F. Provide documentation of the

following certifications: ISO 9001

quality certification.
American Bureau of Shipping (ABS) Product Design Assessment certification. Det Norske Veritas (DNV) certification.
E 90 Fire Testing certification.
VDE certification.

G. Provide ETL test documentation showing cable compression/deformation testing.

1.6. Coordination

A. Coordinate layout and installation of cable tray with other trades.

B. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the

Architect.

C. Storage and Handling: Avoid breakage, denting and scoring finishes. Damaged products will not be installed. Store cable trays and accessories in original cartons and in clean dry space; protect from weather and construction traffic. Wet materials will be unpacked and dried before storage.

2. PRODUCTS

2.1. Manufacturers

A. Note: The listed material, manufacturers, and part numbers are not exhaustive. This is meant to be used as a guideline for all installations. Any deviations from these must be presented to IU Health Telecommunications Department for approval!

B. Subject to compliance with requirements, provide products by the following:

2.2. Materials and Finishes:

A. Cable Tray Materials:

Carbon steel wire, ASTM A 510, Grade 1008. Wire welded, bent, and surface treated after manufacture.

B. Cable Tray Finishes:

Finish for Carbon Steel Wire after welding and bending of mesh;

1. Electrodeposited Zinc Plating: ASTM B 633, Type III, SC-1.
2. Powder-Coated Trays – UL classified Black powder-coated surface treatment over Electrodeposited Zinc Plating (or plain steel) using ASA 61 black polyester coating.

C. Cable tray will consist of continuous, rigid, welded steel wire mesh cable management system, to allow continuous ventilation of cables and maximum dissipation of heat, with UL Classified splices where tray(including UL Classified painted tray) acts as Equipment Grounding Conductor (EGC). Wire mesh cable tray will have continuous Safe-T-Edge T-welded top side wire to protect cable insulation and installers.

D. Provide splices, supports, and other fittings necessary for a complete, continuously grounded system.

Mesh: 2 x 4 inches (50 x 100 mm).
Straight Section Lengths: 118 inches (3,000 mm).
Wire Diameter: Patented design includes varying wire sizes to meet application load requirements; to optimize tray Strength; and to allow tray to remain

lightweight.

Safe-T-Edge: Patented Safe-T-Edge technology on side wire to protect cable insulation and installers' hands.

Fittings: Wire mesh cable tray fittings are field-fabricated from straight tray sections, in accordance with manufacturer's instructions and Item 2.3.

E. CF Series Cable Tray Size:

1. Depth: Cable tray depth will be 4 inches
2. Width: Cable tray width will be 6 ,12, 18, or 24 inches as shown on Telecommunications Drawings:
3. Length: Cable tray section length will be 118 inches (3000mm) unless otherwise shown on drawings.
4. Fill Ratio: Cable tray may be filled to total fill capacity per NEC. Minimum 20% spare capacity recommended to accommodate future cabling changes or additions.
5. Load Span Criteria:
6. Cable tray will be capable of carrying a uniformly distributed load of 50 pounds per foot on an 8 ft. support span, according to load tests of standard shown in Item A above.

2.3. Cable Tray Supports & Accessories

A. Fittings/Supports: Wire mesh cable tray fittings are field-fabricated from straight tray sections, in accordance with manufacturer's instructions. Supports will include the FAS (Fast Assembly System) where possible so that screws, bolts, and additional tools are not required for cable tray mounting; installation time is reduced; and tray path can adapt to installation obstacles without the need for additional parts. Place supports so that support span does not exceed that shown on the drawings.

1. FAS System support methods to mount from ceiling and wall structures with 1/4", 3/8" or 1/2" threaded rod, if applicable
2. Splices, including those approved for electrical continuity (bonding), as recommended by cable tray manufacturer. Select one of the following splicing methods, if applicable:
   a. UL Classified EDRN Fast Splice: No hardware required
   b. UL Classified SWK Splice Washer Kit: Swaged set for splicing, turns, bends, tees
   c. UL Classified ED Universal Splice Bar: Cut & bend to fit any configuration
   d. Preclick Splice: Bolted connection optional
   e. UL Classified EDT Splice Plate: Bolted connection
   f. UL Classified CE 25 & CE 30 Square Splice Washers: Use

with EZ BN ¼" Nut & Bolt

g. UL Classified CE 40 Square Splice Washer: Use with EZ BN ¼" to splice trays on bends, adjustable tees
h. FASLock Splice: For sweeps and bends with tray 12" (300mm) and wider.
i. UL Classified EZ T 90 kit: For Tees and 90s
j. UL Classified RADT90 kit: For 5-1/2" radius Tees and 90s

B. Accessories: As required to protect, support, and install a cable tray system. Select from the following accessories, if applicable:

1. Cable Routing Accessories:

C. Support Accessories:

2.4. Equipment Grounding Conductor Function & Grounding

A. UL Classified cable trays (including painted tray) may act as Equipment Grounding Conductors.

B. Use UL Classified splicing methods to ensure cable tray is electrically continuous and bonded as recommended.

Ground cable trays at end of continuous run.

C. Test cable tray system per NFPA70B, Chapter 18 to verify grounding less than 1 ohm.

D. Ground cable trays against fault current, noise, lightning, and electromagnetic interference by mounting grounding wire to each 10' cable tray section with grounding clamp.

3. EXECUTION

3.1. Examination:

A. Examine substrates for compliance with requirements for installation tolerances and other conditions affecting performance of cable trays. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2. Installation

A. Install cable tray level and plumb according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Cutting: Field-fabricate changes in direction & elevation by cutting & bending cable tray.

1. Cut cable tray wires in accordance with manufacturer's instructions.

2. Cable tray wires must be cut with side-action bolt cutters with offset head to ensure integrity of protective galvanic layer.
3. Remove burrs and sharp edges from cable trays.

C. Vendor Certified Installers

END of SECTION

27 05 39 Surface Raceway for Communication Systems

1. GENERAL

2. PRODUCTS

2.1. Owner Furnished

A. [Include information about systems, products, and accessories that are provided by the owner]

2.2. Manufactured Components

A. Manufacturer List

1. CommScope

B. Product Options

1. Fiber optic cable routing system

C. Scope

1. Fiber patch cord routing and protection system for both overhead and under floor/above suspended ceiling applications.

D. General Requirements

1. The fiber routing system shall mounted in overhead applications.
2. The fiber routing system must be capable of mounting under computer floors and in suspended ceilings.
3. The overhead and under floor/suspended ceiling systems must be modular.
4. The overhead and under floor/suspended ceiling systems shall be used together.
5. The system shall fit restricted, low space applications.
6. Warning labels must be provided to assure that fiber routes are easily recognized.
7. The overhead fiber routing system pieces shall be available in both yellow and black.
8. System must include covers where appropriate.
9. The overhead fiber routing system must be durable and self-supporting.
10. The system must be available in the following dimensions (inches) 2X2, 2X6, 4X4, 4X6, 4X12, and 4X24

E. Fiber Patch Cord Protection

1. The fiber routing system shall provide routing for both fiber optic patch cords (jumpers) 3 mm in diameter and multi-fiber cables.

2. A fiber patch cord bend radius of at least two inches (5.08 cm) shall be maintained at all points in your system.
3. Fiber patch cords shall be easily accessible within the system.
4. The fiber system shall utilize copper trough routes.

F. Overhead System – Equipment Interface

1. There must be efficient transition from the overhead system into fiber frames which safely protects are fibers.

G. Standards

1. All materials in your overhead fiber routing systems must meet UL 94V-0 and Bellcore TR-EOP-000063 standards.
2. All materials used in the systems must comply with NEC and NEBS standards for fire resistance.
3. Fiber raceway product must contain less than .5% halogen material per IEC 61249 and UL746H specifications.
4. The under floor/suspending ceiling system must meet NEC standards for plenum air spaces. Materials used in these spaces must be non-flammable and must not emit appreciable amounts of smoke or toxic gasses when exposed to heat or flame.
5. The under floor/suspended ceiling system must meet grounding requirements as specified in section 300-10 of the National Electric Code (NEC).
6. No System offered can contain nylon or poly-vinyl chloride (PVC) materials.
7. Manuals shall be provided free of charge.
8. The overhead fiber routing system must be both wall and rack mountable.
9. The overhead system must be self-supporting over a six foot span. No additional ironwork or support hardware can be required for its installation.
10. Assembly of piece parts must be purely mechanical. No glue or solvents can be used to assemble the System.

EXECUTION

2.1. INSTALLATION

A. Install all systems in accordance with manufacturer’s printed instructions.

END of SECTION

27 05 43 Underground Ducts and Raceways for Communications Systems

A. Outdoor telecommunications pathways connect building, pedestals, maintenance holes, handholds, and towers. These pathways consist of underground, direct-buried or aerial. Underground or direct-buried are generally preferred over aerial because of aesthetics and security. Generally, underground duct banks are preferred over direct-buried because of security, ease of future cable installation and maintenance.

B. Reference spec 26 0543 Underground Ducts and Raceways for Electrical Systems for additional details not noted in this specification.

C. Conduit Types

Examples of conduit types include:
— EB-20 – For encasement in concrete;
— EB-35 – For encasement in concrete;
— DB-60 – For direct burial or encasement in concrete;
— DB-100 – For direct burial or encasement in concrete;
— DB-120 – For direct burial or encasement in concrete;
— Rigid Nonmetallic Conduit Schedule 40 – For direct burial or encasement in concrete;
— Rigid Nonmetallic Conduit Schedule 80 – For direct burial or encasement in concrete;
— Multiple Plastic Duct (MPD) – For direct burial or installation in conduit;
— Rigid Metallic Conduit – For direct burial or encasement in concrete;
— Intermediate Metallic Conduit – For direct burial or encasement in concrete;
— Fiberglass Duct – For direct burial or encasement in concrete;
— Innerduct Polyethylene (PE) – For direct burial or installation in conduit;
— Innerduct Polyvinyl Chloride (PVC) – For direct burial or installation in conduit

D. Installation

1. The length of conduit between pulling points shall not exceed 600 ft. (183m).
2. Manufactured bends should be used whenever possible. No section of conduit shall contain more than two 90-degree bends, or equivalent between pull points.
3. Conduits should be installed such that a slope exists to allow drainage and prevent the accumulation of water.

4. When conduits connect maintenance holes, a slope of .125 in per foot (10 mm per meter) should exits from the middle of the span to each maintenance hole.
5. Conduits must be buried at a minimum depth of 18 in. (45.7 cm).

END of SECTION

27 05 53 Identification for Communications Systems

1. GENERAL

1.1. Work Includes

Work covered by this Section shall consist of furnishing labor, equipment and materials necessary for the labeling of the telecommunications infrastructure as described on the Drawings and/or required by these specifications.

1.2. Scope of Work

This Section includes the minimum requirements for the Identification and labeling of the Communications Systems for the project as outlined in the Bid Document.

1.3. Summary

A. Administration of the telecommunications infrastructure includes documentation of cables, termination hardware, patching and cross-connection facilities, conduits, other cable pathways, Telecommunications Rooms, and other telecommunications spaces. All facilities shall apply and maintain a system for documenting and administering the telecommunications infrastructure.

B. The owner maintains a campus wide labeling scheme for voice and data outlets and patch panels.

C. Industry Labeling Standards and Conventions shall be used unless otherwise stated in the bid documents or by the Owner's Representative.

D. Telecommunications Infrastructure Records must be maintained in a computer spreadsheet, or in a computer database. Paper records are encouraged, but are optional. A cable record is prepared for each backbone cable. The record will show the cable name, and must describe the origin point and destination point of the cable. The cable record will record what services and/or connections are assigned to each cable pair or strand. An equipment record is prepared for services distributed from a certain piece of equipment, such as a router, or a system such as the telephone system PBX.

E. Installer shall maintain accurate, up-to-date Installation or Construction Drawings. At a minimum, the Installation Drawings shall show pathway locations and routing, configuration of telecommunications spaces including backboard and equipment rack configurations, and wiring details including identifier

assignments.

F. Installer shall provide a complete and accurate set of as-built drawings. The as- built drawings shall record the identifiers for major infrastructure components including; the pathways, spaces, and wiring portions of the infrastructure which may each may have separate drawings if warranted by the complexity of the installation, or the scale of the drawings.

1.4. Quality Assurance

A. All labels shall be installed in a neat and workmanlike manner. All methods of labeling that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative.

B. Labels shall be of the quality and manufacture indicated. The labels and labeling equipment specified are based upon the acceptable manufacturers listed.
Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data labeling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA/EIA - 606-A
Administration Standards.
ANSI/TIA - 569 Pathway and
Spaces
ANSI/TIA - 568 Telecommunications
Cabling Standard BICSI
Telecommunications Distribution
Methods Manual
UL 969 - UL Standard for Safety for Marking and Labeling Systems

1.5. Submittals

Provide product data for the following:
Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.6. Coordination

A. Coordinate installation of labels with other trades.

B. Storage and Handling: Avoid breakage, denting and scoring finishes. Damaged products will not be installed. Store materials in original cartons and in a clean dry space; protect from weather and construction traffic. Wet materials will be unpacked and dried before storage.

2. PRODUCTS

2.1. Manufacturers

2.2. Labels

A. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.

B. Shall be preprinted or computer printed type. Hand written labels are not acceptable.

C. Where insert type labels are used provide clear plastic cover over label.

D. Outside plant labels shall be totally waterproof even when submerged.

E. Equipment Room Copper, Fiber, and Coax Backbone Cable Labels

F. Patch Panel Labels

3. EXECUTION

3.1. Identification & Labeling

A. The size, color, and contrast of all labels should be selected to ensure that the identifiers are easily read. Labels should be visible during the installation of and normal maintenance of the infrastructure.

B. Labels should be resistant to the environmental conditions at the point of installation (such as moisture, heat, or ultraviolet light), and should have a design life equal to or greater than that of the labeled component.

C. All labels shall be printed or generated by a mechanical device.

3.2. Telecommunication Identifiers

A. IU Health labeling standards and practices only

B. Outside Plant cabling shall be clearly marked using permanent means. Outside plant shall use the following system of

numbering and labeling:

1. Fiber Optic:
   a. Identify: far-end building name, building number, fiber-type and strand- count
   b. Label at entrance and exit points of tunnel system and at conduit entry points between 12 inches and 36 inches from the conduit or at closet point that is clearly visible and long cable length in tunnel at 200 foot intervals.
   c. Label at termination panels at both ends.
2. Copper:
   a. Identify: far-end building name, building number and strand-count
   b. Label at entrance and exit points of tunnel system and at conduit entry points between 12 inches and 36 inches from the conduit or at closet point that is clearly visible and long cable length in tunnel at 200 foot intervals.

C. Riser cabling shall be clearly marked using permanent means. Riser cabling shall use the following system of numbering and labeling:

1. Fiber Optic:
   a. Identify: far-end EF / MDF/ IDF, fiber-type and strand-count.
   b. When small facilities are fed from a primary location and treated as an ER, riser shall be labeled similar to Outside Plant Fiber Optic.
2. Copper:
   a. Identify: far-end EF / MDF / IDF and pair-count
   b. Termination points shall be labeled as to actual pair at every fifth (5th) pair-point.

3.3. Labeling Procedures

A. To be consistent with ANSI/TIA/EIA standards and industry practices, it is important that both labeling and color coding be applied to all telecommunications infrastructure components. Labeling with the uniqueidentifier will identify a particular component. Proper color coding will quickly identify how that component is used in the overall telecommunications infrastructure of the facility.

D. Visibility and durability:

1. The size, color, and contrast of all labels should be selected to ensure that the identifiers are easily read. Labels should be visible during the installation of and normal maintenance of the infrastructure.
2. Labels should be resistant to the environmental conditions

at the point of installation (such as moisture, heat, or ultraviolet light), and should have a design life equal to or greater than that of the labeled component.

3. Labels are generally of either the adhesive or insert type. All labels must be legible, resistant to defacement, and maintain adhesion to the application surface.
4. Outside plant labels shall be totally waterproof, even when submerged.
5. Labels applied directly to a cable shall have a clear vinyl wrapping applied over the label and around the cable to permanently affix the label.
6. Other types of labels, such as tie-on labels, may be used. However, the label must be appropriate for the environment in which it is used, and must be used in the manner intended by the manufacturer.

E. Mechanical generation

1. All labels shall be printed or generated by a mechanical device.
2. Hand written labels are NOT acceptable.

END of SECTION

27 10 00 Structured Cabling

27 10 10 General Requirements

A. Transmission performance of structured cabling varies with length, connecting hardware, cords and total number of connections. The installer must take care to properly install the cabling components. To ensure that the installed structured cabling solution meets or exceeds the required performance it must be 'tested' or 'certified'.

B. The requirements for each category of cabling (Cat5e, Cat6, or Cat6A) and optical fiber optics links are located in the ANSI/TIA-568 series standards.

C. Test equipment must meet the requirements set forth in the ANSI/TIA-568 series Standard for Field Test Equipment. All Copper testers shall be Level III. All fiber testers shall meet the requirements in ANSI/TIA-568.

D. Field Power Meters shall meet the following:

Accuracy	± 0.2 dB
Resolution	0.01 dB
Precision	± 0.15 dB

E. The Field light source shall meet the following:

Accuracy	± 0.01 dB
Wavelength	850 ± 30 nm
	1300 ± 50 nm
	1310 ± 30 nm
	1550 ± 30 nm

F. The calibration on all test equipment shall be current.

G. The software in all test equipment shall be current.

H. The requirements for UTG Copper Cabling Infrastructure:

1. To insure system performance throughout the horizontal layer, utilization of end to end UTG cabling and manufacturer's recommended components is required. System performance requirements are set forth by UL and industry approved technology evaluations, to ensure specific extended distances are met.

2. Horizontal infrastructure shall be rated by building life cycle and require a UL verification as follows:

- UTG10, 10-year technology lifecycle, UL Verified B447359
- UTG20, 20-year technology lifecycle, UL Verified B895229

3. Horizontal UTG10 cabling and components will have a transmission performance per ANSI/TIA-568.2-D Balanced Twisted-Pair Telecommunications Cabling and Components, from 1MHz up to a maximum frequency of 425MHz.
4. Horizontal UTG20 cabling and components will have a transmission performance per ANSI/TIA-568.2-D Balanced Twisted-Pair Telecommunications Cabling and Components, from 1MHz up to a maximum frequency between 500-625MHz.

I. Extended Edge Fiber Optic Cabling and Components

1. To insure system performance throughout the extended building edge, utilization of end-to-end UTG cabling and components is required. System performance requirements are set forth by industry approved technology evaluations, to ensure copper loss budgets are maintained.
2. Utilized to extend the distance of devices on a network beyond standard distances of a traditional network. These solutions combine optical fiber for transmission and copper conductors for power typically under one jacket.
3. Extended edge solutions shall meet the following requirements:
   a. Singlemode OS2, low water peak fiber, meet or exceed ITU-T G.652D
   b. Utilize multiple copper conductors within the same sheath as the fiber
   c. Capable of supplying POE power, Type 1, Type 2 and Type 3

27 10 10 Manufacturers

The following manufacturer's testers are approved.

A. FLUKE

1. DTX1800
2. OptiFiber OTDR
3. DTX-CLT CertiFiber Optical Loss Test Set
4. FLUKE DSP 4300

B. Or other test equipment approved by the Owner

The following UTG cable manufacturer's are approved.

C. The extended distance and performance provided by the UTG program relies on cable and connectivity that is tuned in performance to exceed

standards based limitations. A rigorous testing and evaluation process is utilized to qualify UTG manufacturers and UTG components.

D. The qualified manufacturers are CommScope®, Belden and Panduit™ cabling infrastructure products and Fluke Networks® for testing products.

E. Qualified UTG manufacturers shall meet the following requirements:

1. Global manufacturer of communications physical infrastructure
2. Have a complete end to end UTG copper infrastructure solution
3. Have a UTG rated infrastructure technology which meets or exceed the UTG Framework
4. Have a 7-digit UL verification code for copper twisted pair technologies

27 10 20 Systems Testing and Documentation

27 10 20.01 General Requirements

A. Provide installation testing of equipment where required by manufacturer's installation instructions.

B. Provide complete end to end testing for all copper and fiber optic systems/channels based on latest applicable standards. Document all testing and submit with final as-built submittal package.

C. For all controls and operating equipment, submit equipment/systems to at least three complete operational sequences, in which all equipment operations are tested, observed, and verified.

D. Prior to substantial completion and project acceptance inspection, submit test reports to indicated scope of startup and operational tests, with results of testing for each specified operation.

27 10 20.10 Copper Cabling System Testing

A. General: Copper cabling shall be tested and certified after installation as follows and as required for cable manufacturer's warranty. Twisted-pair copper cable channels shall be tested for continuity as specified below, presence of ac/dc voltage, and performance. All cabling shall be tested for conformance to horizontal cable specifications as outlined herein, and shall be tested according to test set manufacturer's instructions utilizing latest firmware and software. Testing shall include all of electrical parameters as specified under Product. All cables and termination hardware shall be 100 percent tested by installation contractor for defects in installation and to verify cable performance under installed conditions. All conductors of each installed cable shall be verified useable by Contractor prior to

system acceptance. All cables shall be tested according to contract documents, manufacturer's warranty provisions, and best industry practices. If any of these are in conflict, Contractor shall comply with most stringent requirements. All defects in cabling system installation shall be repaired or replaced in order to ensure 100 percent useable conductors in all cables installed, at no additional cost to Owner.

B. Continuity: Each pair of each installed cable shall be tested using a test unit that shows opens, shorts, polarity and pair-reversals, crossed pairs and split pairs. The test shall be recorded as pass/fail as indicated by test unit according to manufacturers' recommended procedures, and referenced to appropriate cable identification number and circuit or pair number. Any faults in wiring shall be corrected and cable re-tested prior to final acceptance.

C. Length: Each installed cable link shall be tested for installed length using a TDR type device. The cables shall be tested from patch panel to patch panel, block to block, patch panel to outlet or block to outlet as appropriate. The cable length shall conform to maximum distances set forth in TIA/EIA-568-C standards and all other applicable standards specified in Appendix 1: Codes, Standards, and Informative References. Cable lengths shall be recorded, referencing cable identification number and circuit or pair number. For multi-pair cables, shortest pair length shall be recorded as length for cable.

D. Factory testing: Every reel of cable shall be tested by cable manufacturer for all characteristics specified for cable type in this section. This testing shall be performed using a sweep test method and include frequencies specified for cable. A test report shall be available electronically, at no additional cost, for a minimum of five (5) years from the date of manufacture. The test report shall include the reel number, the date of the test, the Lot number, and test results for Return Loss (RL), Insertion Loss (Attenuation), Pair-to-Pair NEXT, and Power Sum NEXT Pair-to-Pair ELFEXT and Power Sum ELFEXT. The test report shall show the "Worst Case Margin" for the listed transmission characteristics.

E. Test results: Test results shall be automatically evaluated by equipment, using most up-to-date criteria from TIA/EIA-568-C standards and all other applicablestandards specified in Appendix 1: Codes, Standards, and Informative References, and result shown as pass/fail. Test results shall be printed directly from test unit or from a download file using an application from test equipment manufacturer. The printed test results shall

include all tests performed, expected test result and actual test result achieved.

F. Test reports: Test reports for all factory testing and field test reports for copper cabling installation shall be submitted to the Owner's Representative and manufacturer prior to commissioning voice and data system and final contract payment. Refer to Submittals in this Section.

27 10 20.20 Optical Fiber Cable Testing

A. General: Optical fiber cabling shall be tested and certified after installation as described below and as required for cable manufacturer's warranty. Fiber testing shall be performed on all fibers in completed end to end system. Testing shall consist of a bi-directional end to end test in accordance with applicable standards in 27 02 20.20, or a bi-directional end to end test performed by EIA/TIA-455-53A and all other applicable standards in 27 02 20.20. The system loss measurements shall be provided at 850 and 1300 nanometers for multimode type glass and 1310 and 1550 nanometers for single-mode type glass. These tests shall also include continuity checking of each fiber. For spans greater than 90 meters, each tested span must test to a value less than or equal to value determined by calculating a link loss budget. For horizontal spans less than or equal to 90 meters, each tested span must be less than or equal to 2.0 decibels. The insertion loss for each mated optical fiber connector pair shall not exceed 0.40 decibels.

B. Pre-installation testing: Test all optical fiber cable for all fibers prior to installation of cable.

C. Performance testing: Where links are combined to complete a circuit between devices, Contractor shall test each link from end to end to ensure performance of system. Only a basic link test is required. Contractor can optionally install patch cords to complete circuit and then test entire channel. The test method shall be same used for test described above. The values for calculating loss shall be those defined in applicable TIA/EIA standards in Appendix 1: Codes, Standards, and Informative References.

D. Attenuation testing: Attenuation testing shall be performed with a stable launch condition using two-meter jumpers to attach test equipment to cable plant. The light source shall be left in place after calibration and power meter moved to far end to take measurements.

E. Loss budget: All fiber cabling shall be tested at both

wavelengths 850 nm and 1310 nm for multimode and 1300 nm and 1550 nm for single mode.

1. The link attenuation shall be calculated using:
   a) The CommScope Fiber Performance Calculator for CommScope installations
   b) The following calculation for other installations:
      Link Attenuation Allowance (dB) = Cable Attenuation (dB) + Connector loss (dB) + Splice Insertion Loss (dB)
      Where:
      Cable attenuation (dB) = Cable attenuation (dB/km) X Length (km)Connector loss (dB) = Number of Connector pairs X Allowable connector loss (dB)
      Splice Insertion Loss (dB) = Number of Splices X Allowable Splice loss (dB)

F. Link loss: A mated connector to connector interface shall be considered a single connector. Loss numbers for installed link shall be calculated by taking sum of bi- directional measurements and dividing that sum by two. All links not meeting requirements of standard shall be brought into compliance by Contractor, at no additional cost to Owner.

G. Documentation: Following final documentation shall be submitted to the owner's representative prior to commissioning data system and final contract payment according to Submittals in this section.

H. Test results: Test results shall be automatically evaluated by equipment, using most up-to-date criteria from all applicable standards specified in 27 02 20.20 and result shown as pass/fail. Test results shall be printed directly from test unit or from a download file using an application from test equipment manufacturer. The printed test results shall include all tests performed, expected test result and actual test result achieved.

I. End to End Loss Data: final documentation shall be submitted to the owner's representative.

J. As Installed/ As Built Diagrams: Final documentation shall be submitted to the owner's representative.

27 10 20.30 Test Documentation

A. Electronic Format – if required

1. Certification Test Reports shall be submitted in electronic format using the appropriate software supplied by the test equipment manufacturer. The data format should be that

of the test report software (i.e. *.flw files for Fluke). The contractor shall provide any necessary software to view and evaluate the test data.

2. The following list is provided as a reference:

Tester	Test Report Software
Fluke	LinkWare™

3. One electronic copy of the Test Reports shall be provided.

B. Paper Format – if required

1. Provide test documentation in 3-ring binders within 2 weeks after completion of project testing. Binders shall be clearly marked on outside front cover and spine with words Test Results, project name, and date of completion (month and year). Major heading tabs, Horizontal and Backbone, shall divide binder. Each major heading shall be further sectioned by test type. Within horizontal and backbone sections, divide by tabs scanner test results by category, optical fiber attenuation test results, and continuity test results. Present test data within each section in sequence listed in administration records.
2. Provide test equipment by name, manufacturer, model number and last calibration date at the end of document. Unless manufacturer specifies more frequent calibration cycle, annual calibration cycle shall be required on all test equipment used for this installation.
3. Test document shall detail test method used and specific settings of equipment during test. Scanner tests shall be printed on 8 1/2 by 11 inches. Hand written test results (attenuation results and continuity results) shall be documented on a suitable test form.
4. When repairs and re-tests are performed, note problem found and corrective action taken, and collocate in binder both failed and passed test data.

END OF SECTION

27 11 00 Communications Equipment Room Fittings

27 11 16 Communications Racks

1. GENERAL

1.1. Work Includes

A. Provide all labor, materials, and equipment for the complete installation of work called for in the Contract Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for the equipment and cable installations in communications equipment rooms (Telecommunications Closets).

B. Included in this section are the minimum composition requirements and installation methods for the following:

Communication Racks and Rack Cable Management

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of

Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
EIA-310-E, Cabinets, Racks, Panels, and Associated Equipment (most recent version)
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual

1.4. Submittals

A. Provide product data for the following:
B. Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

2. PRODUCTS

2.1. General

A. RACKS

1. Racks shall be manufactured from aluminum and/or steel extrusion.
2. Each rack will have two L-shaped top angles, two L-shaped base angles and two C-shaped equipment-mounting channels. The rack will assemble with nut and bolt hardware. The base angles will be pre-punched for attachment to the floor.
3. Equipment mounting channels will be punched on the front and rear flange with the EIA-310 Universal Mounting hole pattern.
    a. Aluminum Racks will be threaded with 12-24 roll-formed threads and will include 40 each combination pan head, pilot point mounting screws.
    b. Steel Racks will have 3/8” square holes and will include 40 each #12- 24 x ½” mounting screws and 40 each #12-24 cage nuts.

    The rack will include assembly and equipment-mounting hardware. The rack will be rated:
    a. Two Post Racks: 1,000 lb. (453.6 kg) of equipment
    b. Four Post Racks: 2,000 lb. (907.2 kg) of equipment
4. The rack will be UL Listed
5. When assembled with top and bottom angles, equipment-mounting channels will be spaced to allow attachment of 19” EIA rack-mount equipment.

B. RACK CABLE MANAGEMENT

1. Vertical cable management shall have doors that are

lightweight, sturdy, and be available in different sizes to allow flexibility in design.
2. The cable management system shall have a C-Channel bracket that allows for easy access to the cable trough.
3. The vertical cable management system shall allow tool-less installation of Cable Spool.
4. Doors shall come standard with on all cable management and be available in both single and double sided configurations.
5. The door shall have dual hinge design that can be opened to the right or left.
6. The door latching mechanism shall have an easy closing feature.
7. The door shall have one point removal and installation process for door.
8. Horizontal wire managers: The door shall have horizontal cover hinges up or down and be lockable into position with cylindrical finger ends for easy snap on installation
9. The door shall have a recessed handle to eliminate snag potential for clothes and arms.
10. The Horizontal cable management system shall have an open back on 2U and 3U horizontal troughs for easy pass-through of cables

2.2. Free Standing Two Post Aluminum Racks

A. 45U - 7ft (2134 mm) H x 3in (76 mm) Channel x 19in (482.6 mm) Equipment Rack
   1. Rack is to provide 45 rack-mount spaces in a “7 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
   2. For the "7 foot rack" the assembled rack will measure 84" (2133.6 mm) high, 20.4" (518 mm) wide and 15" (381 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.
   3. Finish shall epoxy-polyester hybrid powder coat in the color as specified below.
   4. Approved Manufacturer: CommScope RK3-45A(MID 760082479) Black

B. 52U - 8ft (2438 mm) H x 3in (76 mm) Channel x 19in (482.6 mm) Equipment Rack
   1. Rack is to provide 52 rack-mount spaces in an “8 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
   2. For the "8 foot rack" the assembled rack will measure 96"

(2438 mm) high, 20.4" (518 mm) wide and 15" (381 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.
3. Finish shall be epoxy-polyester hybrid powder coat in the color as specified below.
4. Approved Manufacturer: CommScope RK3-52A (MID 760082487) Black

2.3. Free Standing Two Post Steel Racks

A. 45U - 7ft (2134 mm) H x 3in (76 mm) Channel x 19in (482.6 mm) Equipment Rack

1. Rack is to provide 45 rack-mount spaces in a “7 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
2. For the "7 foot rack" the assembled rack will measure 84" (2133.6 mm) high, 20.4" (518 mm) wide and 15" (381 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.
3. Finish shall be epoxy-polyester hybrid powder coated and textured in Black.
4. Approved Manufacturer: CommScope RK3-45S (MID 760090118)

B. 52U - 8ft (2438 mm) H x 3in (76 mm) Channel x 19in (482.6 mm) Equipment Rack

1. Rack is to provide 52 rack-mount spaces in an “8 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
2. For the "8 foot rack" the assembled rack will measure 96" (2438 mm) high, 20.4" (518 mm) wide and 15" (381 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.
3. Finish shall be epoxy-polyester hybrid powder coated and textured in Black.
4. Approved Manufacturer: CommScope RK3-52S (MID 760090126)

2.4. Free Standing Four Post Aluminum Racks

A. 45U - 7ft (2134 mm) H x 3in (76 mm) Channel x 19in (482.6 mm)

Equipment Rack

1. Rack is to provide 45 rack-mount spaces in a “7 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
2. For the "7 foot rack" the assembled rack will measure 84" (2133.6 mm) high, 20.4" (518 mm) wide and 29" (736.6 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.
3. Finish shall be epoxy-polyester hybrid powder coat in the color as specified below.
4. Approved Manufacturer: CommScope RK4P45-29A (MID 760082529) Black

B. 52U - 8ft (2438 mm) H x 3in (76 mm) Channel x 19in (482.6 mm) Equipment Rack

1. Rack is to provide 52 rack-mount spaces in an “8 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
2. For the "8 foot rack" the assembled rack will measure 96" (2438 mm) high, 20.4" (518 mm) wide and 29" (736.6 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.
3. Finish shall be epoxy-polyester hybrid powder coat in the color as specified below.
4. Approved Manufacturer: CommScope RK4P52-29A(MID 760082537) Black

2.5. Free Standing Four Post Steel Racks

A. 45U - 7ft (2134 mm) H x 3in (76 mm) Channel x 19in (482.6 mm) Equipment Rack

1. Rack is to provide 45 rack-mount spaces in a “7 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
2. For the "7 foot rack" the assembled rack will measure 84" (2133.6 mm) high, 20.4" (518 mm) wide and 29" (736.6 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.

3. Finish shall be epoxy-polyester hybrid powder coated and textured in Black.
4. Approved Manufacturer: CommScope RK-4PE-45-29S (MID 760175703)

B. 52U - 8ft (2438 mm) H x 3in (76 mm) Channel x 19in (482.6 mm) Equipment Rack
1. Rack is to provide 52 rack-mount spaces in an “8 foot rack” for equipment. Each mounting space will be marked and numbered on the mounting channel.
2. For the "8 foot rack" the assembled rack will measure 96" (2438 mm) high, 20.4" (518 mm) wide and 29" (736.6 mm) deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.
3. Finish shall be epoxy-polyester hybrid powder coated and textured in Black.
4. Approved Manufacturer: CommScope RK-4PE-52-29S (MID 760175711)

2.6. Vertical Cable Management For Racks

A. The vertical cable management kits are installed on the side of a 19-inch or 23- inch (483 or 584 mm) wide industry standard rack.

B. The door(s) shall be designed to provide a concealed vertical space for organizing patch cables.

C. Cable spools shall be used to organize longer patch cable lengths.

D. Cable managers are to be matched to the cable rack. Cable managers are available in 6 inch (152 mm), 8 inch (203 mm), 10 inch (254 mm), and 12 inch (305 mm) widths and in 7 foot (2.1 m), 8 foot (2.4 m), and 9 foot (2.7 m) heights.

E. Approved Manufacturer: CommScope

- VCM-SS-84-12B(760089458) 12” single side, vertical cable management, Black door
- VCM-DS-84-6B(760089375) 12” Double side, vertical cable management, Black door
- VCM-DS-84-10B(760089367) 10” Double side, vertical cable management, Black door
- VCM-SS-84-10B(760089441) 10” single side, vertical cable management, Black door

- VCM-SS-84-6B(760089425) 6” single side, vertical cable management, Black door

3. EXECUTION

3.1. Installation

A. Racks and Cable Management

1. Assemble racks and cable management according to manufacturer’s instructions. Verify that equipment mounting rails are sized properly for rack-mount equipment before attaching the rack to the floor.
2. All racks must be attached to the floor in four places using appropriate floor mounting anchors. When placed over a raised floor, threaded rods should pass through the raised floor tile and be secured in the structural floor below.
3. Racks shall be grounded to the TGB using appropriate hardware provided by the contractor. The ground will meet local code requirements and will be approved by the Authority Having Jurisdiction (AHJ).
4. In seismic areas, the rack should have additional bracing as required by building codes and the recommendations of a licensed structural engineer.
5. Ladder rack may be attached to the top of the rack to deliver cables to the rack. The rack should not be drilled to attach ladder rack. Use appropriate hardware from the ladder rack manufacturer.
6. The equipment load should be evenly distributed and uniform on the rack. Place large and heavy equipment towards the bottom of the rack. Secure all equipment to the rack with equipment mounting screws.

END of SECTION

27 11 17 UPS Installation

1. General

1.1. Scope of Work

A. UPS power is required for all Network Equipment. The central utility plant will have a centralized UPS system that will provide power to the MDF. The UPS system is by the EC.

End of Section

27 11 19 Communications Termination Blocks and Patch Panels

1. GENERAL

1.1. Work Includes

A. Provide all labor, materials, and equipment for the complete installation of work called for in the Contract Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Horizontal and Backbone cable terminations installed in communications equipment rooms (Telecommunications Rooms, Equipment Rooms, or "Telecommunications Closets").

B. Included in this section are the minimum composition requirements and installation methods for the following:

Patch Panels

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of

Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
ISO/IEC 11801 - Generic cabling for customer premises CENELEC EN-50173 - Generic cabling systems
BICSI – Telecommunications Distribution Methods Manual

1.4. Submittals

A. Provide product data for the following:

Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

2. PRODUCTS

2.1. Patch Panels

B. Category 6/Class E Patch Panels

1. General specifications: Patch panel shall be constructed of high strength steel with satin chrome finish and designed for wall or 19-inch rack mounting.
2. Panels shall be available in 24-port and 48-port configurations, with height of 1 Rack Unit (RU) of 44.5 millimeters (1.75 inches) for each group of 24 ports.
3. Removable rear mounted cable management bar and front and rear identification labels.
4. Patch panels must be capable of connection to the CommScope Intelligent Patching solution or upgradable to connection to the CommScope Intelligent Patching Solution.
5. Patch panels shall support 5 meter cables in 3 and 4 connector channels, 3 meter cables in 2 connector channels and cross connect cords down to 1 meter.
6. Comply with the standards for Category 6/Class E patch panels listed in the TIA/EIA-568 Series Standards and ISO/IEC 11801.
7. Approved Manufacturer:
   a. CommScope SYSTIMAX VisiPatch Panels
      - VP360-4U-32P(760049445) Visipatch 360 4U (32 ports) kit
      - VP360-12U-96P(760049452) Visipatch 360 12U (96 ports) kit
      - VP360-19PNL-KT(760074278) Visipatch 360 19” 1U Panel kit

C. Category 6A/Class Ea Patch Panels

1. General specifications: Patch panel shall be constructed of high strength steel with satin chrome finish and designed for wall or 19-inch rack mounting.
2. Panels shall be available in 24-port and 48-port configurations, with height of 1 Rack Unit (RU) of 44.5 millimeters (1.75 inches) for each group of 24 ports.
3. Removable rear mounted cable management bar and front and rear identification labels.
4. Patch panels must be capable of connection to the CommScope Intelligent Patching solution or upgradable to connection to the CommScope Intelligent Patching Solution.
5. Patch panels shall support 5 meter cables in 3 and 4 connector channels, 3 meter cables in 2 connector channels and cross connect cords down to 1 meter.
6. Comply with the standards for Category 6A/Class Ea patch panels listed in the TIA/EIA-568 Series Standards and ISO/IEC 11801.
7. Approved Manufacturer:
   a. CommScope SYSTIMAX VisiPatch Panels
      - VP360-4U-32P (760049445) Visipatch 360 4U (32 ports) Kit
      - VP360-12U-96P (760049452) Visipatch 360 12U (96 ports) Kit
      - VP360-19PNL-KT (760074278) Visipatch 360 19” 1U Panel Kit

D. High Density Modular Patch Panels

1. General specifications: Patch panel shall be constructed of high strength steel with black powder finish and designed for wall or 19-inch rack mounting.
2. Panels shall be available in a 48-port configuration, with height of 1 Rack Unit (RU) of 44.5 millimeters (1.75 inches).
3. Panel shall be designed for CommScope Category 6 and 6A Information Outlets.
4. Removable rear mounted cable management bar and front and rear identification labels.
5. Approved Manufacturer:
   a. CommScope SYSTIMAX VisiPatch Panels
      - VP360-4U-32P (760049445) Visipatch 360 4U (32 ports) Kit
      - VP360-12U-96P (760049452) Visipatch 360 12U (96 ports) Kit
      - VP360-19PNL-KT (760074278) Visipatch 360 19” 1U

Panel Kit

A. Fiber Optic Shelf Panels

1. General specifications: Shelves shall be constructed of high strength steel with black powder finish and designed for wall or 19-inch rack mounting.
2. Shelves shall be available in multi U configurations, with height of 1 Rack Unit (RU) 44.5 mm (1.75 in), to 4 RU 177.8 mm (7 in).
3. Removable rear mounted cable management bar, door or cover and front and rear identification labels.
4. Comply with the standards for patch panels listed in the TIA/EIA-568 Series Standards and ISO/IEC 11801.
5. Fiber Shelf Panels shall accept ST, SC or LC modular adapter panels.
6. Approved Manufacturer 1U shelves:
   a. CommScope SYSTIMAX High Density 1U Sliding Modular Cassette Fiber Shelf
      - HD-1U (760209940)

   b. CommScope SYSTIMAX High Density 1U Fiber Shelf Splice Ready
      - HD-1U-SP (760231506)

7. Approved Manufacturer 2U shelves:
   a. CommScope SYSTIMAX High Density 2U Sliding Modular Cassette Fiber Shelf
      - HD-2U (760209957)

   b. CommScope SYSTIMAX High Density 2U Modular Cassette Fiber Shelf Splice Ready
      - HD-2U-SP (760231514)

8. Approved Manufacturer 4U shelves:
   a. CommScope SYSTIMAX High Density 1U Sliding Modular Cassette Fiber Shelf
      - HD-4U (760209965)
   b. CommScope SYSTIMAX High Density 4U Modular Cassette Fiber Shelf Splice Ready
      - HD-4U-SP (760231522)

3. EXECUTION

3.1. Installation

A. All Patch Panels shall be installed in the racks installed in the telecommunications space.

B. Each patch panel shall be attached to the rack using the four

(4) rack screws supplied with the panel

C. All Patch Panels shall be installed level and plum within the racks.

D. Patch Panels shall be installed per the elevation drawings for the Telecommunications space.

END of SECTION

27 11 23 Communications Cable Management and Ladder Rack/Tray

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of work called for in the contract documents.

1.2. Scope of Work

A. This section includes the minimum requirements for the equipment and cable installations in telecommunications rooms.

B. Included in this section are the minimum composition requirements and installation methods for the following:

Ladder Rack/Tray

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the owner or owner representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated or a substitution is requested, equipment shall be equivalent in every way to that of the equipment specified. All substitutions are subject to the control and approval of the owner or the owner representative.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces
ANSI/TIA – 606 Administration Standard for the

Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual NEMA – VE-1 – Metal Cable Tray Systems
NEMA – VE-2 – Metal Cable Tray Installation Guidelines

1.4. Submittals

Provide product data for the following:
Manufacturers' data/cut sheets, product drawing/specifications and installation instructions for all products (submit with bid).

2. PRODUCTS

2.1. Ladder Rack/Tray, Supports, and Accessories

A. Ladder Rack / Tray

1. Ladder rack/tray shall be manufactured from tubular steel. Stringers (sides) will be made from 3/8" wide by 1-1/2" high tubular steel with .065" wall thickness. Cross members (rungs) will be made from 1" wide by ½" high tubular steel with .065" wall thickness.
2. Ladder rack/tray cross members will be welded in between stringers on 9" centers. There will be 8" of open space in between each cross member.
3. Design Make:

B. 12" or 18" Ladder Rack Black

Horizontal 90° turns shall be manufactured from 3/8" wide by 1-1/2" high tubular steel with .065" wall thickness.

1. Stringers (sides) will be formed in a 90° arc. Cross members will be welded in between stringers on approximate 23° increments so that there are 5 cross members per turn. The welded assembly will have an inside radius that will create a smooth horizontal 90° turn.
2. Design Make: CPI Exampl e part

numbe
rs

- Universal Cable Runway (ladder Rack) 9’11”L x 12” W x 1.5”H 10250-712
- Universal Cable Runway (ladder Rack) 9’11”L x 18” W x 1.5”H 10250-718

C. Ladder Rack/Tray Splices

1. Splice kits will provide a method of mechanically connecting ladder rack/tray sections and turns together end-to-end or side-to-end to form a continuous pathway for cables.
2. Design Make: CPI Example part numbers
   - Cable runway butt splice kit for 1.5” stringers 11301-701
   - Junction splice kit for cable runway 1.5: x 0.375” 11302-701

D. Ladder Rack/Tray Accessories

1. Cable straps used for attaching cable bundles to the ladder rack/tray cross members must be reusable with a hook and loop-style closure, at least ¾” wide, and sized for cable bundles that are 2”, 3” or 4” in diameter.
2. Cable retaining posts used to keep cable from falling off of the side of the ladder rack/tray shall be manufactured from 1” by ½” tubular steel with .065” wall thickness. Cable retaining posts will be 8” high and will attach to the side stringer of the ladder rack/tray with included hardware. The top of the cable retaining posts will be fitted with a rubberized end cap to protect cables.
3. End caps used to cover the ends of ladder rack/tray will be manufactured from a black fire-retardant rubberized material. End caps will be sized for 3/8” wide by 1-1/2” high side stingers and will be sold in pairs.
4. Radius drops or “waterfalls” used to maintain the bend Radius of the cables as they exit or enter the ladder rack/tray will be manufactured from aluminum extrusion. The extrusion will be formed in a 90° arc with a minimum bend radius of 3”. Radius drops will attach to either the side stringer or the cross member of the ladder rack/tray using a clevis pin. Radius drops will include 1-1/2” high cable spools that attach to the top of the radius drop to guide cables.
5. Auxiliary support brackets used to support cables that should be physically separated from the cables in the ladder rack/tray will be made from 1/8” x 1” steel bar. The bracket will be L-shaped and will attach to the side stringer of the

ladder rack/tray. The bracket will hang below the ladder rack/tray a minimum of 4". The bracket support surface will be 4" long. The bracket will be zinc plated with a gold chem. finish.

6. Unless otherwise noted, finish on all metal components shall be epoxy- polyester hybrid powder coat (paint) in the color(s) specified below. Hardware will be zinc plated with a gold chem. finish.
7. Design Make:
   Example part numbers

   - Cable Runway wall angle support kit for 18"W runway
     11421-718
   - Triangular wall support bracket for 12"W – 18" W cable runway
     11312-718

3. EXECUTION

3.1. Installation

A. Ladder racking system may be doubled in IDF/MDF if necessary.

B. Provide all components of the ladder rack/tray system (ladder rack/tray, turns, splices, supports, and accessories) from a single manufacturer.

C. Ladder rack/tray shall be installed with side stringers facing down so that the ladder forms an inverted U-shape and so that welds between the stringers (sides) and cross members (middle) face away from cables.

D. Ladder rack/tray shall be secured to the structural ceiling, building truss system, wall, floor or the tops of equipment racks and/or cabinets using the manufacturer's recommended supports and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).

E. Ladder rack/tray splices will be made in mid-span, not over a support, with the manufacturer's recommended splice hardware.

F. Ladder rack/tray shall be supported every 5' or less in accordance with TIA-569. Ladder rack/tray shall be supported within 2' of every splice and within 2' on both/all sides of every intersection. Support ladder rack/tray within 2' on both sides of every change in elevation. Support ladder rack/tray every 2' when attached vertically to a wall.

G. When the pathway is overhead, ladder rack/tray shall be installed with a minimum clearance of 12" above the ladder rack/tray. Leave a

minimum of 12” in between ladder rack/tray and ceiling/building truss structure. Leave a minimum of 3” in between ladder rack/tray and the tops of equipment racks and/or cabinets. Multiple tiers of ladder rack/tray shall be installed with a minimum clearance of 12” in between each tier of ladder rack/tray. When located above an acoustical drop ceiling, leave a minimum of 3” clearance between the top of the drop ceiling tiles and the bottom of the ladder rack/tray.

H. All threaded rod used in support of overhead cable trays shall have cable guard protectors installed over the exposed threaded rod in the area of the tray. The exposed end of the threaded rod hangers shall be cut flush with the mounting brackets, filed, and painted to match site conditions. Install rubber finishing caps on any exposed metal end rail or potential sharp point.

I. When installed under a raised floor, ladder rack/tray shall be installed with a minimum 3” clearance between the top of the ladder rack/tray and the bottom of the floor tiles or floor system stringers, whichever is lower in elevation. Maintain a 3” clearance between ladder racks/trays wherever ladder racks/trays cross.

J. Within each telecommunications room, ladder rack/tray should be bonded together, electrically continuous, and bonded to the TGB, unless otherwise noted in the specifications and contract documents. Ladder rack/tray and turns shall be bonded across each splice with a bonding kit. Ladder rack/tray shall be bonded to the Telecommunications Grounding Busbar (TGB) using an approved ground lug on the ladder rack/tray and a minimum #6 grounding wire or as recommended by the AHJ. Remove paint from the ladder rack/tray where bonding/ground lugs contact the ladder rack/tray so that the lug will contact bare metal. Use antioxidant joint compound in between the bare metal on the ladder rack/tray and ground lug. Use antioxidant joint compound in between the bus bar and the ground lug. Verify continuity through the bonds at splices and intersections between individual ladder rack/tray sections and turns and through the bond to the TGB.

K. The quantity of cables within the ladder rack/tray will not exceed a whole number value equal to 50% of the interior area of the ladder rack/tray divided by the cross-sectional area of the cable. The interior area of ladder rack/tray will be considered to

be the width of the ladder rack/tray multiplied by a height of 2", unless cable retaining posts are added to the ladder rack/tray. The interior area of ladder rack/tray equipped with cable retaining posts will be considered to be the width of the ladder rack/tray multiplied by a height of 6". Actual cable fill for ladder rack/tray that is not equipped with cable retaining posts will not exceed 2" in height. Actual cable fill for ladder rack/tray equipped with cable retaining posts will not exceed 6" in height.

L. The combined weight of cables within the ladder rack/tray will not exceed the stated load capacity of the ladder rack/tray as stated in the manufacturer's product specifications or load/design tables.

M. Cables (cable bundles) will be secured to the cross members of ladder rack/tray with ¾" wide reusable straps. Straps are not required when ladder rack/tray is equipped with cable retaining posts.

N. Use a radius drop to guide cables wherever cable exits overhead ladder rack/tray to access a rack, cabinet or wall-mounted rack, and cabinet or termination field. Provide a support other conductors that should be physically separated from cables within the ladder rack/tray as defined by local code or the authority having jurisdiction (AHJ).

O. Whenever possible, maintain a 2' separation between ladder rack/tray used for communications cables and pathways for other utilities or building services.

P. The installer will provide touch-up paint color-matched to the finish on the ladder rack/tray and will correct any minor cosmetic damage (chips, small scratches, etc.) resulting from normal handling during the installation process prior to delivery to the owner. If a component is cosmetically damaged to theextent that correction in the field is obvious against the factory finish, the component will be replaced with a new component finished from the factory. If a component is physically damaged due to mishandling or modification during the installation process, it shall not be used as part of the ladder rack/tray system.

END of SECTION

27 13 00 Communications Backbone Cabling

27 13 13 Communication Copper Backbone Cabling

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all voice backbone applications called for in the Contract Documents. Provide sufficient pair count to support 100% expansion at the outlet locations.

1.2. Scope of Work

E. This section includes the minimum requirements for Inter and Intra Building Copper Backbone Cables.

F. Included in this section are the minimum composition requirements and installation methods for the following:

Intra-Building Backbone (Inside buildings (ISP)) Inter-Building Backbone (Between buildings (OSP))

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building

Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual

1.4. Submittals

Cable Manufacturer's data, including part numbers, cut sheets and detailed descriptions, for all proposed equipment

The Contractor shall submit installation plan indicating:

1. Equipment and personnel
2. Materials and staging area
3. Start and completion dates
4. Locations, including floor, room and building

The Contractor shall submit a copper cable pulling plan for all multi-pair copper cables with a pair count of 25 pairs or greater, that includes, but is not limited to, the following:

1. Each cable run and route.
2. Date and duration of the pull.
3. Pulling methodology and equipment setups.
4. Pulling tension calculations for each pull in the run.
5. Safety issues and precautions to be taken.

Product data for all termination and test equipment to be used by Contractor to perform work.

1. Equipment shall be calibrated with traceability to National Institute of Standards and Technology (NIST) requirements.
2. Contractor shall include copy of calibration and certification that equipment calibration meets NIST standards and has been calibrated at least once in the previous calendar year.

Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

2. PRODUCTS

2.1. Intra-Building Copper Backbone for Analog/Voice only

A. All cable shall be listed for use per the National Electrical Code (NFPA-70).

B. Cable shall meet one of the following, per bid document:

1. UL-listed CMR cable: Solid copper conductors with high-density polyolefin insulation and overall low smoke PVC jacket to achieve riser (i.e., non- plenum) rating by UL standards
2. UL-listed CMP cable: Solid copper conductors with FEP insulation and overall low smoke PVC jacket to achieve plenum rating by UL standards
3. LSZH cable: Solid copper conductors with non-halogen HDPE insulation and low smoke, zero halogen, compound jacket to achieve LSZH rating by:
   IEC 60754—Part 2.
   IEC 61034—Part 2.
   IEC 60332—Part 1.
   Def Stan 713.

C. Cable shall meet the requirement of ANSI/TIA/EIA-568 series Standards for Category 3 performance.

D. Approved Manufacturer:

1. CommScope, Inc.

   ***Minimum Requirement for MDF to Data 1 will be 25 pair. Based on connection requirements a 50 pair might be required.

   ***Minimum requirements from MDF to Data 2 will be 25 pair.

   ***The appropriate cable rating should be used based on environmental rating of the pathways and spaces.

- 1010 050(106824378) 50 pair riser rated
- 2010 025(107765992) 25 pair plenum rated

2.2. Inter-Building Copper Backbone for Analog/Voice only

A. All cable shall be manufactured and constructed for use in the Outside Plant Environment.

B. Cable shall meet the requirement of ANSI/TIA/EIA-568 series Standards for Category 3 performance

C. Approved Manufacturer:

1. CommScope, Inc.

- Outdoor Multi-pair data cable, 25 pair (999903004)
- Outdoor Multi-pair data cable, 50 pair (999903005)
- Outdoor Multi-pair data cable, 100 pair (999903006)

- Outdoor Multi-pair data cable, 200 pair (999903010)

2.3. Building entrance protection

Building entrance protection for copper cabling shall be installed utilizing a two (2) foot fuse link between outside plant cable plant splice and the protector module with IDC-type input and output terminals, 100 pair-pair capacity and female mounting base, equipped with 230 volt solid state protector modules. Sufficient protector modules shall be provided to completely populate all building entrance terminals.

2.4. Voice backbone cables

Voice backbone cables shall have a minimum 10-foot service loop when terminated in the ER and TR, and at any splice points in telecommunications manholes.

2.5. Protector Panels

2.6. Copper Termination Hardware

D. Main Cross Connect (MC) and Entrance Facility (EF)

1. Approved Manufacturer:
   a. CommScope SYSTIMAX
      - 110AA2-100FT (107058901) 110 field terminated cross-connect system terminal blocks, 20 X 110C-5
      - VP360-4U-32P (760049445) Visipatch 360 4U (32 ports) kit
      - VP360-12U-96P (760049452) Visipatch 360 12U (96 ports) kit
      - VP360-19PNL-KT (760074278) Visipatch 360 19” 1U Panel kit
      - M2000A-48 2U (760207308) U/UTP Modular panel 2U, 48 port angled

3. EXECUTION

3.1. Installation

A. General - Inter and Intra Building Copper Backbone Cable

1. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.
2. Provide all necessary products for installation of Copper

Backbone cablings to include cable attachments, etc.

3. Backbone cable shall be installed following industry standard practices.
4. All Outside Plant Backbone cable shall terminate on Primary protection (per the NEC) upon entering the building.
5. All installations shall comply with:
   ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
   TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
   ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   NFPA 70 – National Electric Code
   BICSI – Telecommunications Distribution Methods Manual

B. Backbone Cable Testing

1. Complete end-to-end test results for all copper UTP cables installed are required.
2. All multi-pair copper cable pairs installed shall be tested to TIA/EIA 568A, Category 3 or Category 6 equivalent performance specifications. In addition, provide loop resistance measurements in ohms and dB loss at 1 KHz, 8 KHz, and 256 KHz.
3. The Owner is to be notified at least 24 hours prior to testing to allow observation at the Owner's discretion. If the Owner confirms his intention to observe, a reasonable starting time shall be agreed upon. Should the Owner not be present at the scheduled commencement time, the Contractor may begin testing as scheduled.
4. 100% of all pairs in backbone copper cables shall be tested for continuity and wire-map.
5. Testing Format: Test Results must be submitted in two (2) formats. First, must be original file(s) downloaded from tester. Second, the file must be cohesively placed in Excel format with the following fields:
   MDF/IDF RM # / RM # of drop / Port # / all relevant test information in as many fields as necessary.
6. All test results are to be recorded and submitted to the Owner.

C. Cable And Termination Panel Labeling

Backbone Cable Testing Label the installed

cables in accordance with Section 27 05 53

D. Cable Support

1. Provide cable supports and clamps to attach cables to backboards and walls.
2. Attach horizontal and vertical backbone cables at 2 foot intervals using Owner approved supports; such as D-rings or jumper troughs utilized for wire management.
3. Attach cables to manhole racks using Owner approved methods
4. Backbone cabling shall be secured to the cable/ladder tray following manufacturer recommended procedures, and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).

E. As-built Drawings

1. CAD Files: Provide CAD files in .dwg, .PDF, or .dgn formats showing floor plans with room numbers and actual backbone cabling and pathway locations and labeling. The deliverable is required within 5 business days of final cable testing.
2. Red Line Drawings: Contract must keep one (1) E size set of floor plans on site during work hours showing installation progress marked and backbone cable labels noted. Contractor may be asked to produce these drawings for examination during construction meetings or field inspections.

END of SECTION

27 13 23 Communication Optical Fiber Backbone Cabling

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Optical Fiber Backbone Cables called for in the Contract Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Optical Fiber Backbone Cables.

B. Included in this section are the minimum composition requirements and installation methods for the following:

Intra Building Backbone (Inside buildings (ISP)) Inter Building Backbone (Between buildings (OSP))

1.3. General Specifications

A. Cables shall be designed for Point To Point applications and shall provide a high level of protection for optical fiber installed in building applications.

B. Higher optical fiber count cables shall utilize a sub-unitized design with color- coded subunits for easy identification.

1.4. Cable Performance Specifications

Cables shall comply with the applicable standards per cable type: Bellcore, fiber distributed data interface (FDDI), and EIA standards
ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable
Telcordia, GR-20-CORE, Generic Requirements for Optical Fiber and Optical Fiber Cable
Telcordia, GR-409-CORE, Generic Requirements for Indoor Fiber Optic Cables Telcordia requirements for superior armored cable
TIA /EI A-568 -C .1
TIA

/EI
A-
568
-C.3
ISO
/IE
C
118
01
CE
NEL
EC
EN-
501
73
EN
187
105

1.5. General - Multimode Fiber

A. Cable shall support current and next generation LAN, SAN, and WAN applications through laser-optimized 50/125 micrometer optical fibers and shall extend distance of low-cost 850 nanometer vertical cavity surface-emitting laser (VCSEL) based electronics

B. Cable shall support dual speed 1 gigabit per second/10 gigabits per second ports, allowing incremental upgrades of switches and servers with less disruption

C. Optical fibers shall be differential mode delay (DMD) tested using a high- resolution test bench that exceeds fiber optic test procedure (FOTP) 220 standards and independently certified by UL.

D. Cable shall also support existing and legacy multi-mode applications that traditionally operate in 850 and 1300 nanometer regions.

1.6. OM4 Multimode Fiber Specification

A. The multimode fibers shall fully meet or exceed the OM4 fiber

specifications in: EN 50173-1:2011
ISO/IEC 11801:2010
IEC/EN 60793-2-10 (A1a fiber)
ANSI/TIA-492AAAD
standards
Local/National Codes

and Regulations

B. The OM4 multimode fiber shall be manufactured with an inside vapor deposition process such as the MCVD (Modified Chemical Vapor Deposition) or PCVD (Plasma Clad Vapor Deposition) processes. Multimode fibers produced with outside vapor deposition processes, such as OVD or VAD, will not be accepted. Inside vapor deposition manufacturing processes results in superior control of Refractive Index Profile required for high bandwidth.

C. The OM4 Multimode Fiber SCS shall be capable of supporting, at minimum, the following IEEE Ethernet applications:

802.3j	10BASE-F 10 Mb/s
802.3j	10BASE-FL 10 Mb/s
802.3u	100BASE-FX 100 Mb/s
802.3u	100BASE-SX 100 Mb/s
802.3z	1000BASE-SX 1000 Mb/s
802.3ae	10GBASE-SR 10Gb/s
802.3aq	10GBASE-LRM 10Gb/s with EDC
802.3ba	40GBASE-SR4 40 Gb/s
802.3ba	100GBASE-SR10 100 Gb/s

D. Additionally the OM4 Multimode Fiber SCS shall be capable of supporting the following Fiber Channel Applications Standards, per Technical Committee 11 of INCITS:

1GFC
2GFC
4GFC
8GFC
10GFC
16GFC

E. The OM4 multimode Fiber shall comply with the following physical specifications:

Cladding Diameter	125 µm
Cladding Diameter Tolerance	±1.0 µm
Cladding NonCircularity, maximum	1%

Coating Diameter (Colored)	254 µm
Coating Diameter (Uncolored)	245 µm
Coating Diameter Tolerance (Colored)	±7 µm
Coating Diameter Tolerance (Uncolored)	±10 µm
Coating/Cladding Concentricity Error, maximum	6 µm
Core Diameter	50.0 µm
Core Diameter Tolerance	±2.5 µm
Core/Clad Offset, maximum	1.5 µm
Numerical Aperture	0.200 ± 0.015
Zero dispersion wavelength	1297 – 1316 nm
Zero dispersion slope	≤ 0.105 ps/nm 2-km
Maximum DMD (note: must comply with at least one of the 6 templates specified below 850 nm 1300 nm	Meets or exceeds TIA/EIA-492AAAC-A and IEC 60793-2-10 A1a.2 See attached templates 0.88 ps/m

F. The OM4 multimode fiber shall meet the following requirements:

Maximum Fiber **Cabled** Loss	3.0 dB/km at 850 nm* 1.0 dB/km at 1300 nm*
Minimum Effective Modal Bandwidth Minimum overfilled Modal Bandwidth	4700 MHz.km at 850 nm (DMD, laser) 500 MHz.km at 1300 nm (DMD, laser) 3500 MHz.km at 850 nm (OFL) 500 MHz.km at 1300 nm (OFL)
Operating Temperature Range (cabled fiber)	-20°C to 50°C (-4°F to 122°F)*
Storage Temperature Range (cabled fiber)	0°C to 50°C (32°F to 122°F) for LSZH -40°C to 65°C (-40°F to 149°F) for others
Maximum Pulling Tension	90 kg
Minimum Tensile Strength	0.7 GPa (100,000 psi)

* NOTE: this value reflects cabled fiber loss. Un-cabled fiber values will not be accepted

G. The OM4 multimode fibers shall be color coded to facilitate individual fiber identification. Color coding shall follow industry standard TIA-598-C Optical Fiber Cable Color Coding

H. The coating shall be mechanically strippable.

I. The OM4 fiber shall meet a minimum of one of the DMD templates listed below, accounting for the wider inner and outer

mask specifications when compared with TIA 492AAAc and IEC 60793-2-10 standards:

J. Differential Mode Delay Testing

The OM4 multimode fiber shall be tested in

accordance with: IEC/EN 60793-1-49
ANSI/TIA-455-220-A
ANSI/TIA-492AAAC-A

K. The following additional enhancements to the DMD tests must be made to ensure high bandwidth:

Enhancement to IEC/EN 60793-1-49 and ANSI/TIA-492AAAC-A standards	
Parameters	**Test Requirement**
Speed of Laser	5 ps pulse width
Scan Resolution (Radial Increment)	1 µm
Inner Mask Radial Coverage	0 – 18 µm (no central hole)
Number of Quadrants Tested	4 quadrants
Test Length	300- 550 meters

L. The Cable Manufacturer must have the capability to test DMD for cabled product. Third party verification of the DMD test bench must be provided with the bid response.

1.7. OS2 Single-mode 8.3 Micrometer Fiber

A. The OS2 Single-mode Fiber SCS shall comply with the

following standards ISO/IEC 11801:2010
EN 50173-1:2011
E
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C
6
0
6
0
3-
7-
4
IEEE 802.3 applications as outlined in section (iii) Local/National Codes and Regulations

B. The OS2 optical fiber glass shall be manufactured from ultra-pure synthetic silica glass. Single-mode fibers manufactured from natural quartz will not be accepted.

C. The OS2 Single-mode Fiber SCS shall be capable of supporting, at minimum, the following IEEE Ethernet applications:

100M	100BASE-LX10
1G	1000BASE-LH
	1000BASE-BX10
	1000BASE-LX10
	1000BASE-PX10-D
	1000BASE-PX10-U
	1000BASE-PX20-D
	1000BASE-ZX
10G	10GBASE-LR
	10BASE-LX4
	10GBASE-ER
40G	40GBASE-LR4
100G	100GBASE-LR4

D. The OS2 single-mode Fiber SCS shall be capable of supporting the following Fiber Channel Applications Standards, per Technical Committee 11 of INCITS:

1GFC
2GFC
4GFC

8GFC
10GFC
16GFC

E. The OS2 single-mode fibers shall fully meet or exceed the specifications in: EN 50173-1:2011
ISO/IEC 11801:2010
IEC/EN 60793-2-50 (b1.3 fiber)
ANSI/TIA-492CAAB
ITU-T G.652.D

F. The OS2 single-mode fiber shall comply with the following physical specifications:

Physical Characteristics	
Cladding Diameter	125.0 ± 0.7 µm
Core/Clad Offset	≤ 0.5 µm
Coating Diameter (Uncolored)	245.0 ± 10 µm
Coating Diameter (Colored)	254.0 ± 7 µm
Coating/Cladding Concentricity Error, Max.	12 µm
Clad Non-Circularity	≤ 1.0 %

G. The OS2 single-mode fiber shall comply with the following mechanical specifications:

Mechanical Characteristics	
Proof Test	100 kpsi (0.69 Gpa)
Coating Strip Force	0.3 – 2.0 lbf (1.3 – 8.9 N)
Fiber Curl	≥ 4 m
Dynamic fatigue Parameter (nd)	≥ 18
Macrobending, Max. (100 turns)	0.05 dB (1,310/1550 nm @50mm) 0.05 dB (1,625 nm @ 60 mm)
Macrobending, Max. (1 turn @32 mm mandrel)	0.05 @1,550 nm

H. The OS2 single-mode fiber shall comply with the following mechanical specifications:

Optical Characteristics, Wavelength Specific			
	1310 nm	1385 nm	1550 nm
Max Attenuation Loose Tube Cable	0.34 dB/km	0.31 dB/km	0.22 dB/km
Max Attenuation Tight Buffer Cable	0.50 dB/km	0.50 dB/km	0.50 dB/km
Mode Field Diameter	9.2 ± 0.3 µm	9.6 ± 0.6 µm	10.4 ± 0.5 µm

Group Refractive Index	1.467	1.468	1.468
Dispersion, Max.	3.5 ps/(nm-km) from 1,285 to 1,330 nm		18 ps/(nm-km)

I. The OS2 single-mode fiber shall comply with the following optical and environmental specifications:

Optical Characteristics, General	
Points defects, Max.	0.10dB
Cut-Off Wavelength	≤ 1260
Zero Dispersion Wavelength	1,302 – 1,322 nm
Zero Dispersion Slope, max.	0.090 ps/[km-nm-nm]
Polarization Mode Dispersion Link Design Value	≤ 0.06 ps/sqrt (km)
Backscatter Coefficient	-79.6/-82.1 dB @ 1310/1550 nm
Index of Refraction	1.466/ 1.467 @ 1310/1550 nm

Environmental Characteristics	
Temperature Dependence -76°F to 185°F (-60°C to 85°C)	≤ 0.05dB
Temperature humidity Cycling 14°F to 185°F (-10°C to 85°C) up to 95% RH	≤ 0.05dB
Water Immersion, 73.4°F (23°C)	≤ 0.05dB
Heat Aging, 185°F (85°C)	≤ 0.05dB

2. EXECUTION

2.1. Installation

A. General - Inter And Intra Building Fiber Backbone Cable

1. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.
2. Provide all necessary products for installation of Fiber Backbone cablings to include cable attachments, etc.
3. Backbone cable shall be installed following industry standard practices.
4. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for fiber cables per manufacturer's specifications.
5. All installations shall comply with:
   ANSI/TIA/EIA – 568 Series Commercial Building Telecommunications Cabling Standard,
   TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
   ANSI/TIA/EIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual

B. Backbone Cable Testing

1. Complete end-to-end test results for all Fiber Optic cables installed are required.
2. All fiber optic cable must be visually inspected and optically tested on the reel upon delivery to the installation site. Using an Optical Time Domain Reflectometer (OTDR), an access jumper with like fiber, a pigtail, and a mechanical splice, all fibers shall be tested for continuity and attenuation.
3. Testing for continuity and attenuation on the reel must confirm factory specifications to ensure that the fiber optic cable was not damaged during shipment. The test results must match the results of the factory-attached tag on the reel, or the fiber shall not be used. Reel data sheet must be provided showing test results.
4. End to end (bi-directional) test measurements shall be provided for single- mode and multimode fibers (2 wavelengths per test are required). Test results must be submitted for review as part of the installation inspection requirements. Test results shall be in paper form and electronic form, and must contain the names and signatures of the technicians performing the tests.
5. Testing shall be performed on 100% of the fibers in the completed end-to- end system. ANSI/TIA-568-A, Annex H, provides the technical criteria and formulae to be used in fiber optic testing. Note however, that all UH fiber must be tested, rated and guaranteed for Ethernet GigaSPEED 1000B-X performance.
6. Additionally, all fiber optic cable links must pass all installation and performance tests both recommended and mandated by the cable manufacturer.
7. The Owner is to be notified at least 24 hours prior to testing to allow observation at the Owner's discretion. If the Owner confirms his intention to observe, a reasonable starting time shall be agreed upon. Should the Owner not be present at the scheduled commencement time, the Contractor may begin testing as scheduled.
8. Testing Format: Test Results must be submitted in two (2) formats. First, must be original file(s) down loaded from

tester. Second, the file must be cohesively placed in Excel format with the following fields:

MDF/TR RM # / RM # of drop / Port # / all relevant test information in as many fields as necessary.

9. All test results are to be recorded and submitted to the Owner.

C. Cable And Termination Panel Labeling

Backbone Cable Testing Label the installed

cables in accordance with Section 27 05 53

D. Cable Support

1. Provide cable supports and clamps to attach cables to backboards and walls.
2. Attach horizontal and vertical backbone cables at 2 foot intervals using Owner approved supports; such as D-rings or jumper troughs utilized for wire management.
3. Attach cables to manhole racks using Owner approved methods
4. Backbone cabling shall be secured to the cable/ladder tray following manufacturer recommended procedures, and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).

E. As-built Drawings

1. CAD Files: Provide CAD files in .dwg, .PDF, or .dgn formats showing floor plans with room numbers and actual backbone cabling and pathway

   locations and labeling. The deliverable is required within 5 business days of final cable testing.
2. Red Line Drawings: Contract must kept one (1) E size set of floor plans on site during work hours showing installation progress marked and backbone cable labels noted. Contractor may be asked to produce these drawings for examination during construction meetings or field inspections.

END of SECTION

27 15 00 Communications Horizontal Cabling

27 15 13 Communication Copper Horizontal Cabling

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Copper Horizontal Cabling applications called for in the Bid Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Copper Horizontal Cables.

B. Horizontal (to desktop) cable shall consist of Category 5E, 6 or 6A copper cable for all Data and Voice applications.

C. At corporate, engineering and campus facilities, horizontal cabling to typical work area outlets (including offices, cubicles and conference rooms) shall consist of four Category 5e or Category 6 cables serving each outlet. At field sales offices, horizontal cabling to typical work area outlets shall consist of two Category 5e or Category 6 cables serving each outlet.

D. Outlets for wall-mounted or other “telephone only” installations shall consist of one Category 6A cable as a minimum.

E. Outlets for wireless access points (APs) shall consist of one Category 6A cables as a minimum.

F. Regarding Data Closets.

1. If there is an addition to an existing closet that currently has 110 blocks and CAT 6 cabling, this standard will be maintained for the addition to match the existing.

2. If there is an addition to an existing closet that currently has 110 blocks and CAT 5 cabling, then Cat 6 cabling and 110 blocks will need to be used for that addition.

3. If this is a brand new closet. It will need to be built using VisiPatch and CAT 6A.

1.3. Quality Assurance

A. Qualified contractors must have a current Bicsi certified

RCDD on staff to perform work on this campus.

B. Qualified contractors must be a Commscope certified Business Partner and capable of offering a 25 year warranty for all Commscope product installed on this campus.

C. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be
equivalent in every way to that of the equipment specified and subject to approval.

D. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

E. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
TIA/EIA-568-C.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards
ISO/IEC 11801 - Generic Cabling for Customer Premises CENELEC EN-50173 - Generic Cabling Systems

1.4. Cable Construction (by Type):

A. Listed CMR cable: Solid copper conductors with high-density polyolefin insulation and an overall low smoke polyvinyl chloride (PVC) jacket to achieve a riser (i.e., non-plenum) rating by applicable NEC requirements.

B. Listed CMP cable: Solid copper conductors with fluorinated ethylene propylene (FEP) insulation and an overall low smoke PVC jacket to achieve plenum rating by applicable NEC requirements.

C. LSZH cable: Solid copper conductors with non-halogen high-density polyethylene (HDPE) insulation and a low smoke, zero halogen, compound jacket to achieve a LSZH rating by applicable IEC standards

D. LC cable: Solid copper conductors with FEP fluoropolymer insulation and overall FEP fluoropolymer jacket to achieve CMP 50 rating by UL standards

E. OSP outdoor cable rated for wet locations: Solid copper conductors with polyethylene insulation, polyolefin fluted center member with flooding compound, and black polyethylene jacket

F. Comply with following general physical specifications:

1. Maximum pulling tension: 110 Newton's (25 pound-force)
2. Operating temperature: –20 to 60 degrees C [–4 to 140 degrees F]

1.5. Submittals

Provide product data for the following:

Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.6. Coordination

Coordinate layout and installation of cable tray with other trades.

2. PRODUCTS

2.1. Data Communications Horizontal Cabling (Category 6/Class E)

A. Category 6/Class E Unshielded Twisted-Pair (UTP) Cable

1. All Cables shall be of round construction
2. Each cable shall contain 4 color coded pairs
3. Cable shall be listed for the environment where it will be installed (Plenum, Riser, LSZH, etc.)
4. Approved Manufacturer:
   a. CommScope SYSTIMAX

- 1071 4 pair (700212046) Riser Cat 6
- 2071 4 pair (700208101) Plenum Cat 6

B. Category 6 horizontal cabling shall provide the following Margin to the specification when installed in a 4 connector Channel:

Electrical Parameter (1-250MHZ)	Guaranteed Margins to Category 6 Class E Channel Specifications
Insertion loss	5%
NEXT	6 dB
PSNEXT	7.5 dB
ELFEXT	6 dB
PSELFEXT	8 dB
Return Loss	4 dB

C. Category 6 horizontal cabling shall meet or exceed the performance specifications listed in the following table when installed in a 4 connector Channel.

Guaranteed Channel Performance Specifications for 4-Connection GigaSPEED XL7 U/UTP Systems										
Freq (MHz)	Insertion Loss (dB)	NEXT (dB)	ACR (dB)	PSNEXT (dB)	PSACR (dB)	ELFEXT (dB)	PSELFEXT (dB)	Return Loss (dB)	Delay (ns)	Delay Skew (ns)
1.0	2.0	71.0	69.0	69.5	67.5	69.3	68.3	23.0	580	30
4.0	3.8	69.0	65.2	68.0	64.2	57.2	56.2	23.0	562	30
8.0	5.4	64.2	58.8	63.1	57.7	51.2	50.2	23.0	557	30
10.0	6.0	62.6	56.6	61.5	55.5	49.3	48.3	23.0	555	30
16.0	7.6	59.2	51.6	58.1	50.4	45.2	44.2	22.0	553	30
20.0	8.6	57.6	49.1	56.5	47.9	43.2	42.2	21.5	552	30
25.0	9.6	56.0	46.4	54.8	45.2	41.3	40.3	21.0	551	30
31.25	10.8	54.4	43.6	53.2	42.4	39.4	38.4	20.5	550	30
62.5	15.6	49.4	33.7	48.1	32.4	33.3	32.3	18.0	549	30
100.0	20.2	45.9	25.7	44.6	24.3	29.3	28.3	16.0	548	30
200.0	30.0	40.8	10.8	39.4	9.4	23.2	22.2	13.0	547	30
250.0	34.1	39.1	5.0	37.7	3.5	21.3	20.3	12.0	546	30

1. The table provides reference values only. All parameters comply with the governing equations over the entire frequency range.
2. All values and equations apply to worst-case channels

utilizing four-pair 71E series cables with full cross-connects, consolidation points and work area outlets (4 connectors in a channel) for any channel lengths up to 100 meters.

D. Category 6 horizontal cabling shall provide the following Margin to the specification when installed in a 6 connector Channel

Electrical Parameter (1-250MHZ)	Guaranteed Margins to Category 6 Class E Channel Specifications
Insertion loss	4%
NEXT	4 dB
PSNEXT	5.5 dB
ELFEXT	4 dB
PSELFEXT	6 dB
Return Loss	2 dB

E. Category 6 horizontal cabling shall meet or exceed the performance specifications listed in the following table when installed in a 6 connector Channel.

Guaranteed Channel Performance Specifications for 6-Connection GigaSPEED XL7 U/UTP Systems										
Freq (MHz)	Insertion Loss (dB)	NEXT (dB)	ACR (dB)	PSNEXT (dB)	PSACR (dB)	ELFEXT (dB)]	PSELFEXT (dB)	Return Loss (dB)	Delay (ns)	Delay Skew (ns)
1.0	2.1	69.0	66.9	67.5	65.4	67.3	66.3	21.0	580	30
4.0	3.9	67.0	63.2	66.0	62.1	55.2	54.2	21.0	562	30
8.0	5.4	62.2	56.7	61.1	55.7	49.2	48.2	21.0	557	30
10.0	6.1	60.6	54.5	59.5	53.4	47.3	46.3	21.0	555	30
16.0	7.7	57.2	49.5	56.1	48.4	43.2	42.2	20.0	553	30
20.0	8.7	55.6	47.0	54.4	45.8	41.2	40.2	19.5	552	30
25.0	9.7	54.0	44.3	52.8	43.1	39.3	38.3	19.0	551	30
31.25	10.9	52.4	41.5	51.2	40.3	37.4	36.4	18.5	550	30
62.5	15.8	47.4	31.6	46.1	30.3	31.3	30.3	16.0	549	30
100.0	20.4	43.9	23.5	42.6	22.1	27.3	26.3	14.0	548	30
200.0	30.3	38.8	8.5	37.4	7.1	21.2	20.2	11.0	547	30
250.0	34.5	37.1	2.6	35.7	1.2	19.3	18.3	10.0	546	30

1. The table provides reference values only. All parameters comply with the governing equations over the entire frequency range.
2. All values and equations apply to worst-case channels utilizing four-pair 71E series cables with up to 6 embedded

connections in a channel for any channel lengths up to 100 meters.

2.2. Data Communications Horizontal Cabling (Category 6A/Class EA)

A. Category 6 Augmented (6A)/Class EA Unshielded Twisted-Pair (UTP) Cable

B. All cables shall be of round construction.

C. Each cable shall contain 4 color coded pairs.

D. Cable shall be listed for the environment where it will be installed (Plenum, riser, LSZH, etc.)

E. Approved manufacturers:
   a. CommScope SYSTIMAX
      - 1091B 4 pair (760107144) Riser Cat 6A
      - 2091B 4 pair (760107268) Plenum Cat 6A
      - 2091B 4 pair (760118521) Plenum Purple Cat 6A for WAP's
      - CCA-CAT6A-PLENUM-WHITE-N018(760235592) Ceiling Connector Assembly

F. Category 6A horizontal cabling shall provide the following Margin to the specification when installed in a 4 connector Channel.

Electrical Parameter (1-250MHZ)	Guaranteed Channel Margins to Amendment 1 to ISO/IEC 11801:2002 "Class E_A"
Insertion loss	3%
NEXT	3 dB
PSNEXT	5 dB
ACR-N	5 dB
PSACR-N	6.5 dB
ACR-F	6 dB
PSACR-F	8 dB
Return Loss	1 dB
Return Loss, PSANEXT, PSAACR-F, Avg. PSANEXT, Avg. PSAACR-F	2 dB

G. Category 6A horizontal cabling shall meet or exceed the performance specifications listed in the following table when installed in a 4 connector Channel.

Guaranteed Channel Performance Specifications for 4-Connection GigaSPEED 360X10D U/UTP Systems

Freq (MHz)	Insertion Loss (dB)	PS ANEXT (dB)	Avg. PS ANEXT (dB)	PS AACR-F (dB)	AVG. PS AACR-F (dB)	NEXT (dB)	ACR-N (dB)	PS NEXT (dB)	PS ACR-N (dB)	ACR-F (dB)	PS ACR-F (dB)	Return Loss (dB)	Delay (ns)	Delay Skew (ns)
1	2.2	82.0	84.3	79.0	83.0	75.7	73.5	75.3	73.1	69.3	68.3	20.0	580	40
4	4.0	76.0	78.2	67.0	71.0	66.0	62.0	65.5	61.5	57.2	56.2	20.0	562	40
8	5.6	73.0	75.2	60.9	64.9	61.2	55.5	60.6	55.0	51.2	50.2	20.0	557	40
10	6.3	72.0	74.3	59.0	63.0	59.6	53.3	59.0	52.7	49.3	48.3	20.0	555	40
16	7.9	70.0	72.2	54.9	58.9	56.2	48.3	55.6	47.7	45.2	44.2	19.0	553	40
20	8.9	69.0	71.2	53.0	57.0	54.6	45.7	54.0	45.1	43.2	42.2	18.5	552	40
25	9.9	68.0	70.3	51.0	55.0	53.0	43.1	52.3	42.4	41.3	40.3	18.0	551	40
31.3	11.1	67.0	69.3	49.1	53.1	51.4	40.3	50.7	39.6	39.3	38.3	17.5	550	40
62.5	15.9	64.0	66.3	43.1	47.1	46.4	30.5	45.6	29.7	33.3	32.3	15.0	549	40
100	20.3	62.0	64.3	39.0	43.0	42.9	22.7	42.1	21.8	29.3	28.3	13.0	548	40
200	29.2	57.5	59.7	33.0	37.0	37.8	8.6	36.9	7.7	23.2	22.2	10.0	547	40
250	32.9	56.0	58.3	31.0	35.0	36.1	3.2	35.2	2.3	21.3	20.3	9.0	546	40
300	36.2	54.8	57.1	29.5	33.5	34.7	-1.5	33.8	-2.5	19.7	18.7	8.2	546	40
400	42.3	53.0	55.2	27.0	31.0	32.6	-9.8	31.6	-10.8	17.2	16.2	7.0	546	40
500	47.8	51.5	53.8	25.0	29.0	30.9	-17.0	29.8	-18.0	15.3	14.3	7.0	546	40

1. The table provides reference values only. All parameters comply with the governing equations over the entire frequency range.
2. All values and equations apply to worst-case channels utilizing four-pair 91A series cables with full cross-connects, consolidation points and work area outlets (4 connections in a channel) for the length up to 100 meters.

1. PART3 – EXECUTION

3.1. Installation

A. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.

B. Cable shall be installed following industry standard practices.

C. Horizontal cabling shall be installed from the work area outlet location to the nearest Telecommunications Space.

D. Horizontal cabling shall be terminated on a patch panel in the telecommunication space which is the same category rating as the Cable. i.e. Cat 6 cable terminates on Cat 6 panels.

E. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for twisted pair cables per

manufacturer's specifications.

F. Contractor shall test all horizontal links per the ANSI/TIA-568 Requirements.

END of SECTION

27 15 23 Communication Optical Fiber Horizontal Cabling

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Optical Fiber Horizontal Cabling applications called for in the Bid Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Optical Fiber Horizontal Cables.

B. At corporate, engineering, field sales offices and campus facilities, horizontal cabling to typical work area outlets (including offices, cubicles and conference rooms) shall consist of two or more strands of fiber serving each outlet.

C. When deemed as a requirement, fiber to the desktop shall require a minimum of 4 strands of fiber. All other fiber optic applications shall be specified with a minimum 100% growth allocation.

D. Unless otherwise stated in the Bid and/or Engineering Documents, all horizontal (to desktop) cable shall consist of OM3 or OM4 laser optimized 50/125 micrometer micron optical fibers and shall extend distance of low-cost 850 nanometer vertical cavity surface-emitting laser (VCSEL) based electronics, supporting following list of application standards.

1. Cable shall support dual speed 1 gigabit per second/10 gigabits per second ports, allowing incremental upgrades of switches and serving with less disruption.
2. Optical fibers shall be differential mode delay (DMD) tested using a high- resolution test bench that exceeds fiber optic test procedure (FOTP) 220 standards and independently certified by UL.
3. The optical fiber shall couple sufficient power from light emitting diode (LED) sources to support legacy applications such as Ethernet, token ring, FDDI, Fast Ethernet, and ATM. In addition, 50 micrometer core size shall be directly compatible with laser-based applications, as follows:
    a. Ethernet from 10 megabits per second to 10 gigabits per second
    b. Fiber channel from 1 to 10 gigabits per second
    c. ATM/synchronous optical networking (SONET)/synchronous digital hierarchy (SDH) from OC-1 to OC-192

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association(TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual Bellcore, fiber distributed data interface (FDDI), and EIA standards ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable
Telcordia’s Generic Requirements for Optical Fiber and Optical Fiber Cable Telcordia requirements for superior armored cable
TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
TIA/EIA-568-C.3 – Optical Fiber Cabling Components Standard ISO/IEC 11801 - Generic Cabling for Customer Premises
CENELEC EN-50173 - Generic Cabling Systems

1.4. Cable Construction (by Type):

A. Listed OFNP cable: fiber buffer and cable jacket materials that have low smoke, low flame propagation characteristics that achieve a plenum rating by applicable NEC requirements.

B. Listed OFNR cable: fiber buffer and cable jacket materials that have low smoke, low flame propagation characteristics that achieve a plenum rating by applicable NEC requirements.

C. LSZH cable: fiber buffer and cable jacket materials that have non-halogen , low smoke, low flame propagation characteristics that achieve a OFN-LS rating by applicable NEC and IEC requirements.

1.5. Submittals

Provide product data for the following:

Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.6. Coordination

Coordinate layout and installation of cable tray with other installations.

2. PRODUCTS

2.1. Indoor Armored, UL Rated, Tight Buffered Distribution Cable

A. Basis for Design Specifications: CommScope SYSTIMAX optical fiber cable, in strand-count identified on the bid document, and with the metallic armor of the

appropriate jacket material (OFNR, OFNP, LSZH) for the global region in which the cable will be installed.

B. Cable construction:

1. Tight buffer optical fibers, aramid strength yarn, and UL rated jacket.
2. Interlocking armor spiraling around premises distribution style cable, with an overall sheath jacket to provide additional protection and security
3. Aluminum armor
4. Available in either Plenum, Riser or LSZH listing
5. Sheath color-coded to optical fiber type and printed with relevant cable information on cable

C. Approved Manufacturer:

CommScope SYSTIMAX

Example

Catalog/Manufacturer Part Number

- P-012-DZ-5K-FSUAQ (760127647) (Plenum 12F for NAR)
- ***Required for connection between MDF and DATA 1
- P-024-DZ-8W-FSUYL (760127886) SM Armored plenum 24 Strand
- ***(2 X 24 strand SM fiber are required for connection between the MDF and Data 1 closet. Must be in separate paths)
- ***Required for connection between MDF and Data 2
- P-012-DZ-5K-FSUAQ (760128017) OM4 armored plenum 12 strand

2.2. OM4 Multimode Fiber Specification

A. The multimode fibers shall fully meet or exceed the OM4 fiber specifications in: EN 50173-1:2011
ISO/IEC 11801:2010
IEC/EN 60793-2-10 (A1a fiber)
ANSI/TIA-492AAAD
standards
Local/National Codes
and Regulations

B. The OM4 multimode fiber shall be manufactured with an inside vapor deposition process such as the MCVD (Modified Chemical Vapor Deposition) or PCVD (Plasma Clad Vapor Deposition) processes. Multimode fibers produced with outside vapor deposition processes, such as OVD or VAD, will not be accepted. Inside vapor deposition manufacturing processes results in superior control of Refractive Index Profile required for high bandwidth.

C. The OM4 Multimode Fiber SCS shall be capable of supporting, at minimum, the following IEEE Ethernet applications:

802.3j	10BASE-F 10 Mb/s

802.3j	10BASE-FL 10 Mb/s
802.3u	100BASE-FX 100 Mb/s
802.3u	100BASE-SX 100 Mb/s
802.3z	1000BASE-SX 1000 Mb/s
802.3ae	10GBASE-SR 10Gb/s
802.3aq	10GBASE-LRM 10Gb/s with EDC
802.3ba	40GBASE-SR4 40 Gb/s
802.3ba	100GBASE-SR10 100 Gb/s

D. Additionally the OM4 Multimode Fiber SCS shall be capable of supporting the following Fiber Channel Applications Standards, per Technical Committee 11 of INCITS:

1GFC
2GFC
4GFC
8GFC
10GFC
16GFC

E. The OM4 multimode fiber shall comply with the following physical specifications:

Cladding Diameter	125 µm
Cladding Diameter Tolerance	±1.0 µm
Cladding NonCircularity, maximum	1%
Coating Diameter (Colored)	254 µm
Coating Diameter (Uncolored)	245 µm
Coating Diameter Tolerance (Colored)	±7 µm
Coating Diameter Tolerance (Uncolored)	±10 µm
Coating/Cladding Concentricity Error, maximum	6 µm
Core Diameter	50.0 µm
Core Diameter Tolerance	±2.5 µm

Core/Clad Offset, maximum	1.5 µm
Numerical Aperture	0.200 ± 0.015
Zero dispersion wavelength	1297 – 1316 nm
Zero dispersion slope	≤ 0.105 ps/nm2-km
Maximum DMD (note: must comply with at least one of the 6 templates specified below 850 nm 1300 nm	Meets or exceeds TIA/EIA-492AAAC-A and IEC 60793-2-10 A1a.2 See attached templates 0.88 ps/m

F. The OM4 multimode fiber shall meet the following requirements:

Maximum Fiber **Cabled** Loss	3.0 dB/km at 850 nm*
	1.0 dB/km at 1300 nm*
Minimum Bandwidth	4700 MHz.km at 850 nm (DMD, laser) 500 MHz.km at 1300 nm (DMD, laser) 3500 MHz.km at 850 nm (OFL) 500 MHz.km at 1300 nm (OFL)
Operating Temperature Range (cabled fiber)	-20°C to 50°C (-4°F to 122°F)*
Storage Temperature Range (cabled fiber)	0°C to 50°C (32°F to 122°F) for LSZH -40°C to 65°C (-40°F to 149°F) for others
Maximum Pulling Tension	90 kg
Minimum Tensile Strength	0.7 GPa (100,000 psi)

* NOTE: this value reflects cabled fiber loss. Un-cabled fiber values will not be accepted

G. The OM4 multimode fibers shall be color coded to facilitate individual fiber identification. Color coding shall follow industry standard TIA-598-C Optical Fiber Cable Color Coding

H. The coating shall be mechanically strippable.

I. The OM4 fiber shall meet a minimum of one of the DMD templates listed below, accounting for the wider inner and outer mask specifications when compared with TIA 492AAAc and IEC 60793-2-10 standards:

J. Differential Mode Delay Testing

The OM4 multimode fiber shall be tested in

accordance with: IEC/EN 60793-1-49
ANSI/TIA-455-220-A
ANSI/TIA-492AAAC-A

K. The following additional enhancements to the DMD tests must be made to ensure high bandwidth:

Enhancement to IEC/EN 60793-1-49 and ANSI/TIA-492AAAC-A standards	
Parameters	Test Requirement
Speed of Laser	5 ps pulse width
Scan Resolution (Radial Increment)	1 µm
Inner Mask Radial Coverage	0 – 18 µm (no central hole)
Number of Quadrants Tested	4 quadrants
Test Length	300- 550 meters

L. Third party verification of the DMD test bench must be provided with the bid response.

2.3. OS2 Single-mode 8.3 micrometer Fiber

A. The OS2 Single-mode Fiber SCS shall comply with the following standards

ISO/IEC 11801:2010
EN 50173-1:2011
EN 50173-2:2010 ANSI/TIA-568-C IEC 60603-7-4
IEEE 802.3 applications as outlined in section (iii)
Local/National Codes and Regulations

B. The OS2 optical fiber glass shall be manufactured from ultra-pure synthetic silica glass. Single-mode fibers manufactured from natural quartz will not be accepted.

C. The OS2 Single-mode Fiber SCS shall be capable of supporting, at minimum, the following IEEE Ethernet applications:

100M	100BASE-LX10
1G	1000BASE-LH
	1000BASE-BX10
	1000BASE-LX10
	1000BASE-PX10-D
	1000BASE-PX10-U
	1000BASE-PX20-D
	1000BASE-ZX
10G	10GBASE-LR
	10BASE-LX4
	10GBASE-ER
40G	40GBASE-LR4
100G	100GBASE-LR4

D. The OS2 single-mode Fiber SCS shall be capable of supporting the following Fiber Channel Applications Standards, per Technical

Committee 11 of INCITS:

1GFC
2GFC
4GFC
8GFC
10GFC
16GFC

E. The OS2 single-mode fibers shall fully meet or exceed the specifications in: EN 50173-1:2011
ISO/IEC 11801:2010
IEC/EN 60793-2-50 (b1.3 fiber)
ANSI/TIA-492CAAB
ITU-T G.652.D

F. The OS2 single-mode fiber shall comply with the following physical specifications:

Physical Characteristics	
Cladding Diameter	125.0 ± 0.7 µm
Core/Clad Offset	≤ 0.5 µm
Coating Diameter (Uncolored)	245.0 ± 10 µm
Coating Diameter (Colored)	254.0 ± 7 µm
Coating/Cladding Concentricity Error, Max.	12 µm
Clad Non-Circularity	≤ 1.0 %

G. The OS2 single-mode fiber shall comply with the following mechanical specifications:

Mechanical Characteristics	
Proof Test	100 kpsi (0.69 Gpa)
Coating Strip Force	0.3 – 2.0 lbf (1.3 – 8.9 N)
Fiber Curl	≥ 4 m
Dynamic fatigue Parameter (nd)	≥ 18
Macrobending, Max. (100 turns)	0.05 dB (1,310/1550 nm @50mm) 0.05 dB (1,625 nm @ 60 mm)
Macrobending, Max. (1 turn @32 mm mandrel)	0.05 @1,550 nm

H. The OS2 single-mode fiber shall comply with the following mechanical specifications:

Optical Characteristics, Wavelength Specific			
	1310 nm	1385 nm	1550 nm

Max Attenuation Loose Tube Cable	0.34 dB/km	0.31 dB/km	0.22 dB/km
Max Attenuation Tight Buffer Cable	0.50 dB/km	0.50 dB/km	0.50 dB/km
Mode Field Diameter	9.2 ± 0.3 µm	9.6 ± 0.6 µm	10.4 ± 0.5 µm
Group Refractive Index	1.467	1.468	1.468
Dispersion, Max.	3.5 ps/(nm-km) from 1,285 to 1,330 nm		18 ps/(nm-km)

I. The OS2 single-mode fiber shall comply with the following optical and environmental specifications:

Optical Characteristics, General	
Points defects, Max.	0.10dB
Cut-Off Wavelength	≤ 1260
Zero Dispersion Wavelength	1,302 – 1,322 nm
Zero Dispersion Slope, max.	0.090 ps/[km-nm-nm]
Polarization Mode Dispersion Link Design Value	≤ 0.06 ps/sqrt (km)
Backscatter Coefficient	-79.6/-82.1 dB @ 1310/1550 nm
Index of Refraction	1.466/ 1.467 @ 1310/1550 nm

Environmental Characteristics	
Temperature Dependence -76°F to 185°F (-60°C to 85°C)	≤ 0.05dB
Temperature humidity Cycling 14°F to 185°F (-10°C to 85°C) up to 95% RH	≤ 0.05dB
Water Immersion, 73.4°F (23°C)	≤ 0.05dB
Heat Aging, 185°F (85°C)	≤ 0.05dB

3. EXECUTION

3.1. Installation

A. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.

B. Cable shall be installed following industry standard practices.

C. Horizontal cabling shall be installed from the work area outlet location to the nearest Telecommunications Space.

D. Horizontal cabling shall be terminated on a patch panel in the telecommunication space which is the same category rating as the Cable. i.e. Cat 6 cable terminates on Cat 6 panels.

E. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for twisted pair cables per

manufacturer's specifications.

F. Contractor shall test all horizontal links per the ANSI/TIA-568 Requirements.

END of SECTION

27 15 43 Communications Faceplates and Connectors

27 15 43.10 Communications Copper Jack/Information Outlets and Connectors

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Jack/Information outlets and connections called for in the Bid Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Jack/Information outlets and Connectors.

B. The channel performance for the installation shall meet or exceed the requirements of ANSI/TIA-568 and ISO/IEC 11801 for the specified Category.

C. The Jack/Information outlets shall match the category of the cabling

D. All jacks/information outlets shall meet UL 94 V-O

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
Bellcore, fiber distributed data interface (FDDI), and EIA standards
ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable

Telcordia's Generic Requirements for Optical Fiber and Optical Fiber Cable
TIA/EIA-568-C .1
TIA/EIA-568-C.2
TIA/EIA-568-C.3
ISO/IEC 11801
CENELEC EN-50173

1.4. Submittals

Provide product data for the following:

Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.5. Coordination

Coordinate installation of Jack/Information outlets and connectors with other trades.

2. PRODUCTS

2.1. General

A. All products will be compliant to RoHS 2002/95/EC

B. All products will be designed, manufactured and/or distributed under this quality management system: ISO 9001:2008

C. Telecommunications jacks shall be 8-position/8-conductor modular outlets accepting industry standard modular RJ45 type plugs and insulation displacement conductor (IDC) terminations.

D. The Universal design shall support T568A wiring and shall have universal wiring labels, including color-coded insert identification labels to ensure accurate identification.

E. Color shall be specified or selected by Owner's Representative from manufacturer's standard colors.

F. Provide crosstalk cancellation with compensation and alien crosstalk mitigation using printed wiring board materials and compensation technology.

G. Jack shall be backward compatible with lower category cords and cables.

H. Low-profile wire cap shall protect against contamination and secure connection. Jacks shall be suitable for:

1. Modular patching applications or as modular TO
2. Installation without special faceplates at either 45- or a 90-degree angle in manufacturer's modular faceplates and frames, including those on surface-mounted boxes

I. Dimensions

1. Depth: 30.48 mm (1.20 in)
2. Height : 20.32 mm (0.80 in)
3. Width : 20.32 mm (0.80 in)

J. Electrical Specifications

1. Contact Resistance Variation, maximum: 20 Mohm
2. Contact Resistance, maximum: 100 Mohm
3. Current Rating : 1.5 A @ 20 °C, 1.5 A @ 68 °F

4. Dielectric Withstand Voltage, RMS, conductive surface : 1500 Vac @ 60 Hz
5. Dielectric Withstand Voltage, RMS, contact-to-contact : 1000 Vac @ 60 Hz
6. Insulation Resistance, minimum : 500 Mohm

K. Environmental Specifications

1. Flammability Rating: UL 94 V-0
2. Operating Temperature: -10 °C to +60 °C (+14 °F to +140 °F)
3. Relative Humidity : Up to 95%, non-condensing
4. Safety Standard: cUL , UL
5. Storage Temperature: -40 °C to +70 °C (-40 °F to +158 °F)

L. Mechanical Specifications

1. Conductor Type: Solid, Stranded (7 strands)
2. Material Type: Copper alloy, High-impact, flame retardant, thermoplastic
3. Outlet/Module Contact Plating: Precious metals
4. Plug Insertion Life, minimum: 750 times
5. Plug Insertion Life, test plug: IEC 60603-7 compliant plug
6. Plug Retention Force, minimum: 30 lbf, 133 N
7. Rear Termination Contact Plating: Precious metals
8. Rear Termination Type: IDC
9. Wiring: T568A
10. Can be mounted either at 90 degrees (straight) or 45 degrees (angled)
11. Angled feature eliminates the need for special faceplates

2.2. Category 6/Class E Outlets

A. GigaSPEED® XL MGS400 Series Category 6 U/UTP Information Outlet

B. Electrical performance guaranteed to meet or exceed TIA/EIA 568-C.2 Category 6 and ISO/IEC Category 6/Class E specifications.

C. Optional Plastic Icons (M61A) and Dust Covers (M20A) available in several colors

D. Backward compatible with Category 5e, 5 and 3 cords and cables, however optimal performance achieved when used with GigaSPEED XL GS8E patch cords.

E. Can support network line speeds in excess of 1 gigabit per second.

F. Qualifies for a 20-year product and applications assurance warranty when included as part of a certified SYSTIMAX GigaSPEED XL channel.

G. Approved Manufacturer:

a. CommScope SYSTIMAX

- 700206717 – CAT 6 Ivory Hospitals
- 700206725 – CAT 6 White Clinics

2.3. MGS400-246 – Cat 6 Ivory Category 6 Augmented (6A)/Class EA Outlets

A. GigaSPEED® X10D MGS600 Series Information Outlet

B. Patented crossing of straddling pair contacts enables efficient alien crosstalk reduction in the channel.

C. Optional Plastic Icons (M61A) and Dust Covers (M20A) available in several colors.

D. Optimal performance is achieved when using the GigaSPEED X10D 360GS10E patch cords; however, the MGS600 is fully backwards compatible.

E. Can support network line speeds up to at least 10 gigabits per second.

F. Qualifies for the SYSTIMAX 20-Year Extended Product Warranty and Applications Assurance when included as part of a registered SYSTIMAX GigaSPEED X10D channel.

G. Approved Manufacturer:

a. CommScope SYSTIMAX

- 760092411 – CAT 6A Ivory Hospital
- 760092429 – CAT 6A White Clinic

3. EXECUTION

3.1. Installation

A. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.

B. Jack/Information outlets and Connectors shall be installed following industry standard practices.

C. Horizontal cabling shall be terminated on a Jack/Information outlet which is the same category rating as the Cable. i.e. Cat 6 cable terminates on Cat 6 Jack/Information outlets.

D. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for twisted pair cables per manufacturer's specifications.

E. Contractor shall test all horizontal links per the ANSI/TIA-568 Requirements.

END of SECTION

27 15 43.15 Communications Fiber Connectors, Adapters and Adapter Panels

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Fiber Connectors, Adapters and Adapter Panels called for in the Bid and Engineering Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Fiber Connectors, Adapters and Adapter Panels.

B. The performance for the installation shall meet or exceed the requirements of ANSI/TIA-568 and ISO/IEC 11801 and other requirements as noted in this specification for the specified Fiber Type.

C. The connectors and adapters shall match the fiber type of the cabling

D. All connectors and adapters shall meet UL 94 V-O

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
Bellcore, fiber distributed data interface (FDDI), and EIA standards
ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable
Telcordia's Generic Requirements for Optical Fiber and Optical Fiber Cable
TIA/EIA-568-C.3 – Optical Fiber Cabling Components Standard
ISO/IEC 11801 - Generic Cabling for Customer Premises
CENELEC EN-50173 - Generic Cabling Systems

1.4. Submittals

Provide product data for the following:
Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.5. Coordination

Coordinate installation of Jack/Information outlets and connectors with other trades.

2. PRODUCTS

2.1. General

A. All products will be:

1. Compliant to RoHS 2002/95/EC
2. Designed, manufactured and/or distributed under this quality management system: ISO 9001:2008

2.2. LC Fiber Adapters

A. Multimode adapter for use with 50/125 OM2+,OM3 and OM4 Fiber

1. Color – Aqua
2. Alignment Sleeve Material - Phosphorous bronze
3. Approved Manufacturer:
   (Following Catalog Number/Part numbers are provided as examples, see CommScope representative for assistance in selecting the proper adapters and connectors)
   a. CommScope SYSTIMAX
   - MFA-LC02-AQ 108622887 LC Duplex Adapter, Aqua, single pack
   - 360DP-24LC-LS 760115907 360 Distribution panel 24 fiber
   - 360DP-12LC-LS 760109363 360 Distribution panel 12 fiber
   - DM12-24LC-LS-ULL 760236110 ULL G2 OM4 fiber module 24 fiber.
   - HD 1U 760209940 High Density 1U fiber shelf
   - HD 2U 760209957 High Density 2U fiber shelf
   - HD 4U 760209965 High Density 4U fiber shelf

B. Single-mode adapter for use with G.652.D or G.652.D, OS2 fiber

1. Color – Blue
2. Alignment Sleeve Material - Zirconia
3. Approved Manufacturer
   (Following Catalog Number/Part numbers are provided as examples, see CommScope representative for assistance in selecting the proper adapters and connectors)
   a. CommScope SYSTIMAX
   - SFA-LC02-BL (700002215) TeraSPEED LC Duplex Adapter, Blue, Single pack
   - SFA-LC01-BL (700002132) TeraSPEED LC Simplex Adapter, Blue, Single pack
   - 360DP-24LC-SM (760115915) 360 Distribution panel 24 fiber
   - 360DP-12LC-SM (760109389) 360 Distribution panel 12 fiber
   - DM12-24LC-SM-ULL (760238083) ULL G2 SM Fiber Module 24 fiber
   - HD-1U (760209940) High Density 1U fiber shelf
   - HD-2U (760209957) High Density 2U fiber shelf
   - HD-4U (760209965) High Density 4U fiber shelf
   - HD-1U-SP (760231506) high density 1U fiber splice shelf
   - HD-2U-SP (760231514) high density 2U fiber splice shelf

2.3. LC Fiber Connectors

A. Multimode Connector for use with OM1, OM2+, OM3 and OM4 fiber

1. Color – Beige
2. Ferrule Geometry - Pre-radiused

3. Ferrule Material - Zirconia
4. Performance meets or exceeds ANSI/TIA/EIA-568-C.3 standard
5. Insertion Loss, typical - 0.17 dB
6. Return Loss, minimum - 20.0 dB
7. Insertion Loss Change, mating - 0.30 dB
8. Insertion Loss Change, temperature - 0.30 dB
9. Approved Manufacturer:
   (Following Catalog Number/Part numbers are provided as examples, see CommScope representative for assistance in selecting the proper connectors)
   - CommScope SYSTIMAX
     - MFC-LCR-16-BG 760034140 LC Connector simplex for 1.6mm fiber cordage, multimode.
     - MFC-LCR-09-BG 760034181 Behind the wall LC connector for 0.9mm buffered fiber, multimode
     - MDC-LCR-16-BG 760034157 Pre-radiused LC Duplex connector for 1.6mm fiber cordage, multimode.

B. Single-mode Connector for use with G.652.D or G.652.D, OS2 fiber

1. Color – Blue
2. Ferrule Geometry - Pre-radiused
3. Ferrule Material - Zirconia
4. Performance meets or exceeds ANSI/TIA/EIA-568-C.2 standard
5. Insertion Loss, typical - 0.20 dB
6. Return Loss, minimum - 55.0 dB
7. Insertion Loss Change, mating - 0.30 dB
8. Insertion Loss Change, temperature - 0.30 dB
9. Approved Manufacturer:
   (Following Catalog Number/Part numbers are provided as examples, see CommScope representative for assistance in selecting the proper connectors)
   - CommScope SYSTIMAX
     - SFC-LCR-16-BL 760034173 Pre-radiused LC connector simplex for 1.6mm fiber cordage.
     - SFC-LCR-09-BL 760034199 Behind the wall pre-radiused LC connector for 0.9mm buffered fiber
     - SDC-LCR-16-BL 760091439 Pre-radiused LC Duplex connector for 1.6mm fiber cordage

C. LC Connectors with mechanical splice

1. Color coded per industry standard requirements to aide in identification during and after installation
2. Factory pre-polished for field installation
3. Mechanical splice technology
4. Must include a factory pre-cleaved fiber stub and a proprietary index-matching gel
5. Options for single mode and multimode fibers
6. Compatible with 250µm and 900µm optical fibers

7. Performance exceeds ANSI/TIA/EIA-568-C.2 standard
8. Complete tool kit with cleaning solution, wipes, and scrap fiber container designed for quick setup and tear-down
9. Factory-installed wedge clip shall be included with each connector; wedge is discarded upon completion of the termination
10. Translucent wedge shall enable the use of a common VFI to provide a "pass/fail" signal once physical contact is achieved
11. Capability to be re-terminated if the first installation fails
12. Shall not require a custom termination kit
13. Approved Manufacturer:
    (Following Catalog Number/Part numbers are provided as examples, see CommScope representative for assistance in selecting the proper connectors)
    - CommScope
        - MFC-LCF-09-5X 760117887 LazrSPEED fiber Qwik II-LC Connector, Aqua fiber types: OM2+, OM3, OM41 per pack
        - MFC-LCF-09-5X-25 760117911 LazrSPEED fiber Qwik II-LC Connector, Aqua fiber types: OM2+, OM3, OM41. 25 per pack
        - SFC-LCF-09-8X 760117895 TeraSPEED fiber Qwik II-LC Connector, blue fiber types: G.652.D, G657.A1 or G.652.D, G657.A1, OS2. 1 per pack
        - SFC-LCF-09-8X-25 760117929 TeraSPEED fiber Qwik II-LC Connector, blue fiber types: G.652.D, G657.A1 or G.652.D, G657.A1, OS2. 25 per pack
        - MFC-LCF-09-6X 760117903 OptiSPEED fiber Qwik II-LC Connector, Beige fiber type: OM1. 1 per pack
        - MFC-LCF-09-6X-25 760117937 OptiSPEED fiber Qwik II-LC Connector, Beige fiber type: OM1. 25 per pack

3. EXECUTION

3.1. Installation

A. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to

any unique codes or requirements governed by the region where the work is to be performed.

B. Fiber Connectors, Adapters and Adapter Panels shall be installed following industry standard practices.

C. Horizontal cabling shall be terminated on a Fiber Connectors, Adapters and Adapter Panels which is designed for the fiber type of the cable. i.e. Single mode cable terminates on Single mode Connectors and Adapters.

D. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for twisted pair cables per manufacturer's specifications.

E. Contractor shall test all horizontal links per the Relevant Standards and Requirements.

END of SECTION

27 15 43.25 Work Area Faceplate/Wall Plates and Surface Mount Boxes

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Faceplate/wall plates and Surface mount Boxes called for in the Bid Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Faceplate/wall plates and Surface mount Boxes.

B. All Faceplates and Surface Mount boxes shall be constructed of high-impact, flame retardant; UL rated 94 V-0 Thermoplastic.

C. Faceplates and SMB shall be designed to accept the CommScope SYSTIMAX information outlets.

D. Number of outlets per faceplate shall be as detailed on the Telecommunications Drawings.

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control

and approval of the Owner or Owner Representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
TIA/EIA-568-C.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA/EIA-568-C.3 – Optical Fiber Cabling Components Standard
ISO/IEC 11801 - Generic Cabling for Customer Premises CENELEC EN-50173 - Generic Cabling Systems

1.4. Submittals

Provide product data for the following:

Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.5. Coordination

Coordinate installation of Faceplate/wall plates and Surface mount Boxes with other trades.

2. PRODUCTS

2.1. Faceplates and Surface Mount Boxes (SMB)

A. Approved Manufacturer:
(Following Catalog Number/Part numbers are provided as examples, see CommScope representative for assistance in selecting the proper faceplates and SMBs)

a. CommScope

- 108168477 – Flush mount faceplate, two port Ivory – Hospital
- 108168469 – Flush mount faceplate, two port White – Clinic
- 108168550– Flush mount faceplate, four port Ivory – Hospital
- 108168543 – Flush mount faceplate, four port White – Clinic
- 107984049 – Surface mount box, dual port Ivory – Hospital
- 107984056 – Surface mount box, dual port White – Clinic
- 760117572 – 1 port single gang stainless steel non-standard telephone faceplate.

2.2. Dust Covers for Faceplates and Surface Mount Boxes (SMB)

A. Dust Covers shall be dual purpose blank covers designed for use with modular outlets and faceplates. They shall be used to cover the outlet opening of all empty faceplate openings and unpopulated jacks to protect the wires from collecting dust.

B. Approved Manufacturer:
(Following Catalog Number/Part numbers are provided as examples, see CommScope representative for assistance in selecting the proper faceplates and SMBs)

a. CommScope

- 107067860 Dust cover for M-series faceplates and outlets Ivory
- 108066457 Dust cover for M-series outlets Ivory
- 107067928 Dust cover for M-series faceplates and outlets White

- 108066465 dust cover for M-series outlets White

3. EXECUTION

3.1. Installation

1. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.
2. Faceplate/wall plates and Surface mount Boxes shall be installed following industry standard practices.
3. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for twisted pair cables per manufacturer's specifications.
4. Contractor shall test all horizontal links per the ANSI/TIA-568 Requirements.

END of SECTION

27 16 00 Communications Connecting Cords, Devices and Adapters

27 16 19 Communications Patch Cords, Station Cords, and Cross-Connect Wire

27 16 19.02 Copper Patch Cords

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Copper Patch cords into the approved patch panels called for in the Bid Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Copper Patch Cords.

B. All Patch/Equipment Cords shall be new.

C. On new installations, Patch/Equipment Cords shall be made by the same manufacturer as the Horizontal Cable used in the new installation.

D. Patch/Equipment Cords shall be available in multiple colors. Colors required are to be detailed in the Bid Documents.

E. All Patch/Equipment Cords shall be factory manufactured and tested for compliance to the appropriate standards and performance.

F. Patch/Equipment Cord length shall be determined by the end user.

G. Patch/Equipment Cords shall be installed using proper cable management.

H. Minimum bend radius shall not be exceeded.

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications

Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable
Telcordia, GR-20-CORE, Generic Requirements for Optical Fiber and Optical Fiber Cable

1.4. Submittals

Provide product data for the following:
Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.5. Coordination

Coordinate layout and installation of Patch/Equipment Cords with other trades.

2. PRODUCTS

2.1. Category 6 /Class E Patch Cords

A. The Modular Patch Cords shall meet or exceed TIA ANSI/TIA-568-C.2 Category 6 and ISO/EIC Category 6/Class E specifications and shall be fully backward compatible with Category 5e and 5 connectors.

1. Approved Manufacturer:
(The following Catalog/Part numbers are shown as examples, contact your CommScope Representative to specify correct Catalog/Part numbers)
   a. CommScope SYSTIMAX
      - CPC3312 – 01F007 GigaSPEED XL GS8E Stranded cordage modular patch cord.
      - CPC3372 – 01F007 GigaSPEED XL GS8E Solid Plenum Cable modular patch cord.
      - CPC3392 – 01F007 GigaSPEED XL GS8E Stranded LSZH Cordage modular patch cord.

B. The IDC Patch Cords shall meet or exceed TIA ANSI/TIA-568-C.2 Category 6 and ISO/EIC Category 6/Class E specifications and shall be fully backward compatible with Category 5e and 5 connectors.

1. Approved Manufacturer:
(The following Catalog/Part numbers are shown as examples, contact your CommScope Representative to specify correct Catalog/Part numbers)
   a. CommScope SYSTIMAX
      - CPCFF12 – 01F007 GigaSPEED XL VP360 to VP360 4 pair patch cord.
      - CPCF312 – 01F007 GigaSPEED XL VP360 to RJ45 GS8E 4 pair Hybrid patch cord.
      - CPCFF62 – 01F007 VisiPatch 360 to VisiPatch 360 1 pair patch cord.

2.2. Category 6 Augmented (6A)/Class EA Patch Cords

A. The Modular Patch Cords shall meet or exceed the channel specifications of Amendment 1 to ISO/IEC 11 801:2002 Class EA and ANSI/TIA-568-C.2 Category 6A up to 500 MHz when used as part of a UTP Channel.

1. Approved Manufacturer:
(The following Catalog/Part numbers are shown as examples, contact your CommScope Representative to specify correct Catalog/Part numbers)
   a. CommScope SYSTIMAX
      - CPCSSX2 – 02F007 GigaSPEED X10D 360GS10E Solid cordage modular patch cord
      - CPCSSY2 – 02F007 GigaSPEED X10D 360GS10E Solid Plenum Cordage modular patch cord
      - CPCSSZ2 – 02F007 GigaSPEED X10D 360GS10E Solid LSZH cordage modular patch cord

B. The IDC Patch Cords shall meet or exceed the channel specifications of Amendment 1 to ISO/IEC 11 801:2002 Class EA and ANSI/TIA-568-C.2 Category 6A up to 500 MHz when used as part of a UTP Channel.

1. Approved Manufacturer:
(The following Catalog/Part numbers are shown as examples, contact your CommScope Representative to specify correct Catalog/Part numbers)
   a. CommScope SYSTIMAX
      - CPCFFX2 – 01F007 GigaSPEED X10D VP360 to VP360 4 pair solid patch cord.
      - CPCFFZ2 – 01F007 GigaSPEED X10D VP360 to VP360 4 pair solid LSZH patch cord.
      - CPCFSX2 – 01F007 GigaSPEED X10D VP360 to RJ45 4 pair solid hybrid patch cord.
      - CPCFSZ2 – 01F007 GigaSPEED X10D VP360 to RJ45 4 pair LSZH solid hybrid patch cord.

3. EXECUTION

3.1. Installation

A. Copper Jumpers/patch cables

1. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.
2. Cable shall be installed following industry standard practices.
3. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for copper cables per manufacturer's specifications.
4. All installations shall comply with:
   ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
   TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
   ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding

(Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual

END of SECTION

27 16 19.03 50 Micron Multimode Optical Fiber Cords and Pigtails

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all 50 Micron Multimode Optical Fiber Cords and Pigtails into the approved patch panels called for in the Bid Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Fiber Patch Cords.

B. All Patch/Equipment Cords shall be new.

C. On new installations, Patch/Equipment Cords shall be made by the same manufacturer as the Horizontal Cable used in the new installation.

D. Patch/Equipment Cords shall be available in multiple colors. Colors required are to be detailed in the Bid Documents.

E. All Patch/Equipment Cords shall be factory manufactured and tested for compliance to the appropriate standards and performance.

F. Patch/Equipment Cord length shall be determined by the end user.

G. Patch/Equipment Cords shall be installed using proper cable management.

H. Minimum bend radius shall not be exceeded.

1.3. Quality Assurance

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding

(Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual
ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable
Telcordia, GR-20-CORE, Generic Requirements for Optical Fiber and Optical Fiber Cable

1.4. Submittals

Provide product data for the following:
Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.5. Coordination

Coordinate layout and installation of Fiber Cords and Pigtails with other trades.

2. PRODUCTS

2.1. Optical Fiber Patch Cords and Pigtails

To maintain channel integrity, optical fiber patch cords and pigtails shall be fabricated to meet the performance parameters corresponding to the optical fiber cable approved product type specified below. Patch cord and pigtail plug connectors shall be equipped with boots, and shall have same colors as related optical fiber backbone cables, unless specified or indicated otherwise. Optical fiber patch cords and pigtails shall be available with the following options as indicated on the bid document.

2.2. Termination types:

A. LC Patch cord outside diameters:

1. Simplex: 1.6 mm (0.063 in)
2. Duplex: 1.6 mm x 3.3 mm (0.063 in x 0.130 in)
3. Pigtails: Ruggedized and tight-buffered optical fiber, 0.9 mm (0.035 in) outside diameter

B. SC and ST Patch cord outside diameters:

1. Simplex: 3.0 mm (0.118 inches)
1. Duplex: 3.0 mm x 5.9 mm (0.063 in x 0.232 in)
2. Pigtails: Ruggedized and tight-buffered optical fiber, 0.9 mm (0.035 in) outside diameter

C. Lengths: As specified in the bid document

D. Basis for Design Specifications: CommScope SYSTIMAX LazrSPEED 550 multimode optical fiber, with the appropriate jacket material (OFNR or OFNP) for the pathway in which the cable will be routed. NOTE: All CommScope 50 micron optical jumpers are constructed using OM4 fiber.

E. Approved Manufacturer

1. CommScope SYSTIMAX
Example Catalog/Manufacturer Part Number (Note: contact CommScope Representative for assistance for construction of Trunk Catalog/Part

numbers.)

FEXLCLC42 – MXMxxx – A 2 fiber optic jumper, riser, LazrSPEED 550 Multimode glass with LC connectors on both ends. Substitute xxx in part number with actual length in meters.

3. EXECUTION

3.1. Installation

A. Fiber Optic Jumpers/patch cables

1. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.
2. Cable shall be installed following industry standard practices.
3. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for fiber cables per manufacturer's specifications.
4. All installations shall comply with:
   ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
   TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
   ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   NFPA 70 – National Electric Code
   BICSI – Telecommunications Distribution Methods Manual

END of SECTION

27 16 19.05 Single-mode Optical Fiber Cords and Pigtails

1. GENERAL

1.1. Work Includes

Provide all labor, materials, and equipment for the complete installation of all Single-Mode Optical Fiber Cords and Pigtails into the approved patch panels called for in the Bid Documents.

1.2. Scope of Work

A. This section includes the minimum requirements for Fiber Patch Cords.
B. All Patch/Equipment Cords shall be new.
C. On new installations, Patch/Equipment Cords shall be made by the same manufacturer as the Horizontal Cable used in the new installation.
D. Patch/Equipment Cords shall be available in multiple colors. Colors required are to be detailed in the Bid Documents.
E. All Patch/Equipment Cords shall be factory manufactured and tested for compliance to the appropriate standards and performance.
F. Patch/Equipment Cord length shall be determined by the end user.
G. Patch/Equipment Cords shall be installed using proper cable management.
H. Minimum bend radius shall not be exceeded.

1.3. Quality Assurance

I. All cable and equipment shall be installed in a neat and workmanlike manner.
All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative.
J. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.
K. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
L. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:
ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,

TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
NFPA 70 – National Electric Code
BICSI – Telecommunications Distribution Methods Manual ANSI/ICEA S-87-640,
Standard for Optical Fiber Outside Plant Communications Cable
Telcordia, GR-20-CORE, Generic Requirements for Optical Fiber and Optical Fiber Cable

1.4. Submittals

Provide product data for the following:
Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

1.5. Coordination

Coordinate layout and installation of Fiber Cords and Pigtails with other trades.

2. PRODUCTS

2.1. Optical Fiber Patch Cords and Pigtails

To maintain channel integrity, optical fiber patch cords and pigtails shall be fabricated to meet the performance parameters corresponding to the optical fiber cable approved product type specified below. Patch cord and pigtail plug connectors shall be equipped with boots, and shall have same colors as related optical fiber backbone cables, unless specified or indicated otherwise. Optical fiber patch cords and pigtails shall be available with the following options as indicated on the bid document.

2.2. Termination types:

M. LC Patch cord outside diameters:
1. Simplex: 1.6 mm (0.063 in)
2. Duplex: 1.6 mm x 3.3 mm (0.063 in x 0.130 in)
3. Pigtails: Ruggedized and tight-buffered optical fiber, 0.9 mm (0.035 in) outside diameter

N. SC and ST Patch cord outside diameters:
1. Simplex: 3.0 mm (0.118 inches)
2. Duplex: 3.0 mm x 5.9 mm (0.063 in x 0.232 in)
3. Pigtails: Ruggedized and tight-buffered optical fiber, 0.9

mm (0.035 in) outside diameter

O. Lengths: As specified in the bid document

P. Basis for Design Specifications: CommScope SYSTIMAX TeraSPEED Single-mode optical fiber, with the appropriate jacket material (OFNR or OFNP) for the pathway in which the cable will be routed.

Q. Approved Manufacturer
Example Catalog/Manufacturer Part Number (Note: contact CommScope Representative for assistance for construction of Trunk Catalog/Part numbers.)
1. CommScope
   - FWELCLC42 – JXMxxx – A 2 fiber optic jumper, riser, TeraSPEED Single mode glass with LC connectors on both ends. Sutstitute xxx in part number with actual length in meters.

3. EXECUTION

3.1. Installation

R. Fiber Optic Jumpers/patch cables
1. Contractor shall comply applicable codes, standards and with all local codes and requirements. It is the responsibility of the contractor to identify and adhere to any unique codes or requirements governed by the region where the work is to be performed.
2. Cable shall be installed following industry standard practices.
3. Contractor shall not exceed the maximum pulling tension or the minimum bending radius for fiber cables per manufacturer's specifications.
4. All installations shall comply with:
   ANSI/TIA – 568 Series Commercial Building Telecommunications Cabling Standard,
   TIA – 569 Commercial Building Standard for Telecommunications Pathways and Spaces,
   ANSI/TIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   NFPA 70 – National Electric Code
   BICSI – Telecommunications Distribution Methods Manual

END of SECTION

27 53 19 Distributed Antenna System (DAS)

1. GENERAL

1.1. Section Includes

This Specification describes technical and performance criteria for deploying a Neutral-Host Distributed Antenna System (DAS) capable of supporting Wireless Service Providers (WSP) and Public Safety Networks (PSN).

1.2. System Description

A. Upon commissioning the DAS shall provide coverage for AT&T, Verizon, and Sprint in the local market. IU Health may add or omit WSPs at their discretion. Support for all WSPs is desirable, but in certain circumstances it may not be required.
B. The DAS shall support all commercial licensed bands from 380-2700 MHz.
C. The DAS shall have expansion capabilities to support new licensed bands without replacing any existing hardware.
D. The DAS shall have the capabilities to support both interleaved MIMO and 2x2 MIMO if necessary.
E. The system architecture shall be designed for CommScope Era™ and consist of: WIN – Wireless Intelligent Node
CAN – Central Access Node
TEN – Transport
Extension Node
APs – Access
Points
UAP – Universal Access Points
CAP-L – Carrier Access Point Low Power
CAP-M – Carrier Access Point Medium Power
F. The proposed commercial DAS shall utilize structured cabling that complies with the following specifications:
1. ISO/IEC 11801 and EN 50173-1 Category 6A/Class EA cabling specifications or ANSI/TIA-568-C Category 6A cabling specifications for balanced cabling.
2. ISO/IEC 1101, EN 50173-1, and ANSI/TIA-568.D-3 for OM3 or OM4 specifications for multimode optical fiber cabling.
3. ISO/IEC 11801, EN 50173-1, and ANSI/TIA-568.D-3 for OS1 specifications for single mode optical fiber cabling
- Commscope GigaSPEED x 10D cabling.
- Commscope LazrSPEED 300 or 550 cabling
- Commscope TeraSPEED x 10D

G. The DAS shall self-detect its components and send alarm

notifications when it detects network issues.

H. The Contractor shall propose and deploy a DAS with an RF design and installation that meets the requirements in order to enable WSP approval for interconnection to the WSPs' macro networks or BTS equipment.

I. The system will not be turned on without WSP acceptance and retransmission agreement. Contractor is responsible to obtain WSP approval. Contractor is responsible to ensure the RF design adapts to the carrier requirements in all stages of the project.

J. The Contractor working with the end user customer is responsible for confirming that the site has the necessary space and power to support the DAS as well as the RF Sources and identify the potential power required for Cellular Base Stations.

K. Network Management:
   1. NMS: The DAS shall have a Network Management System (NMS) capable of alarm, monitor, configuration, and control of all Active Components.
   2. SNMP Integration: The DAS NMS shall be capable of integration with the 3rd party SNMP based NMS products for alarm purposes and provide alarming information.

1.3. Alternatives

A. No alternative component(s) shall be accepted as equal to the components and manufacturers specified in this document unless the Contractor proves that the alternative component(s) are of equal or superior specifications and quality, and that they have been used in similar projects of size and complexity for no less than 3-years. The following information shall be required for each alternative component with submittal of the bid response:
   1. Passive Components:
      A. Detailed product specifications
   2. Active Components:
      A. Hardware and software manuals
      B. Detailed product specifications
      C. Mean Time Between Failure (MTBF) data for each Active Component

1.4. Codes, Standards, and Certifications

A. All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance, and testing shall comply with the latest editions of the National Electric Code, National Electrical Safety Code, and all applicable local

rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of a discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.

1.5. Performance Requirements

A. On a per channel basis, the downlink received signal level for each frequency band shall meet or exceed the criteria specified for the application as defined in the RFP.
B. Contractor in their response shall identify the specific market criteria requested by each respective WSP.
C. It is the Contractor's responsibility to confirm that all design requirements for each respective WSP are met with their proposed solution.
D. Contractor shall state the assumed channel loading and frequency bands for the proposed WSP in-building coverage. Prior to installation, contractors shall confirm the channel loading and frequency use in the serving area, and shall guarantee coverage for these channels per the criteria in the RFP.
E. The DAS shall deliver converge throughout 85% of the building. Unless stated separately in the floor plans it is expected coverage including stairwells, elevators, basement, and garage.

1.6. Submittals

A. Submittal Requirements with Bid Response:
    1. Product Datasheets
    2. Shop Drawings: Submit the following items:
        a. Overlay of System Components on floor plans
        b. Propagation SISO design based on assumed WSP design targets of -98 dBm RSCP for LTE and -75 dBm for UMTS. Assume all WSP RF sources are BTS fed.
        c. Bill-of-Material
    3. Statement of Work (SOW): Submit sample SOW

4. Acceptance Test Plan (ATP): Submit sample ATP
5. Recommended Spares
6. Letter from manufacturer confirming authorization for solution.
7. Warranty Documents:
    a. Submit for all manufactured components specified in this section.
    b. Submit Contractor's System Warranty

B. Submittal Requirements Prior to Start of Construction.
1. Final RF link budget.
2. Overlay of system components on floor plans.
3. RF propagation modeling.
4. Bill-of-Material (BOM)
5. Maintenance Service Contract (Optional)
6. Statement of Work (SOW): The contractor shall submit a SOW that has been accepted by IU Health's designated representative.
7. Acceptance Test Plan (ATP): The contractor shall submit an ATP that has been accepted by IU Health's designated representative.

C. Submittal Requirements at Close Out
1. Drawings: Submit as-built drawings indication:
    a. Cable routing and coverage antenna locations.
    b. Active component locations, layout, and configuration.
2. Test Reports
    a. WSP DAS: Submit accepted ATP reports
3. Field Reports: Submit test results for the cabling infrastructure.
4. Operation and Maintenance Data: Submit hardware and software manuals for all active components.
5. Warranty Documents:
    a. Submit for all manufactured components specified in this section.
    b. Submit Contractor's System Warranty.

1.7. Quality Assurance

A. Qualifications: Contractor, and/or Sub-Contractors, shall

have a minimum of 5-years full-time experience executing work of similar scope and complexity.

B. Certifications:
   1. Passive Components: Contractor or Sub-Contractor shall provide manufacturer certification that their personnel have been trained on the components being installed.
   2. Active Components: Contractor or Sub-Contractor shall provide manufacturer certification that their personnel have been trained on the components being installed.

1.8. Maintenance

A. The Contractor shall provide an optional maintenance service contract, covering for a period of one-year: preventative maintenance, system monitoring, spares, fault, mitigation, equipment repair, and response time.

1.9. Contractor Credentials

A. The Contractor shall document their relations with the equipment manufacturer, certifications with the manufacturer, and significant success stories.

2. PRODUCTS

2.1. Manufacturers

A. CommScope Era

2.2. Components

A. DAS Head End Equipment
1. Approved Manufacturer: CommScope Central Access Node (CAN)

B. DAS Remote Units
1. Approved Manufacturer: CommScope Transport Extension Node (TEN)

C. C-RAN Integration Units
1. Approved Manufacturer: CommScope Wireless Integration Node (WIN)

D. Access Points
   1. Approved Manufacturer: CommScope
      a) Universal Access Point (UAP)
      b) Carrier Access Point Low Power (CAP-L)
      c) Carrier Access Point Medium Power (CAP-M)

3. EXECUTION

3.1. Installation

A. The Contractor shall design, install, commission, and test the DAS in accordance with the manufacturer's instructions and recommendations.
B. The Contractor shall install the DAS in accordance with the accepted SOW.

3.2. Acceptance Testing

A. Acceptance testing will be performed confirming the requirements of Section 1.6 have been met.
B. The Contractor shall complete the acceptance testing as prescribed in the approved Acceptance Test Plan (ATP) submittal.

END of SECTION

SECTION 281300 - ACCESS CONTROL FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Security access central-control station.
2. One or more security access networked workstations.
3. Security access operating system and application software.
4. Security access controllers connected to high-speed electronic-data transmission network.

1.3 DEFINITIONS

A. CPU: Central processing unit.

B. Credential: Data assigned to an entity and used to identify that entity.

C. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.

D. GFI: Ground fault interrupter.

E. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.

F. I/O: Input/Output.

G. LAN: Local area network.

H. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.

I. PC: Personal computer. Applies to the central station, workstations, and file servers.

J. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed

data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.

K. PDF: Portable Document Format. The file format used by the Acrobat document-exchange- system software from Adobe.

L. RAS: Remote access services.

M. RF: Radio frequency.

N. ROM: Read-only memory. ROM data are maintained through losses of power.

O. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

P. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.

Q. UPS: Uninterruptible power supply.

R. USB: Universal serial bus.

S. WAN: Wide area network.

T. WAV: The digital audio format used in Microsoft Windows.

U. WMP: Windows media player.

V. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.

W. Windows: Operating system by Microsoft Corporation.

X. Workstation: A PC with software that is configured for specific, limited security-system functions.

Y. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Diagrams for cable management system.

2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
   a. Workstation outlets, jacks, and jack assemblies.
   b. Patch cords.
   c. Patch panels.
4. Cable Administration Drawings: As specified in "Identification" Article.
5. Battery and charger calculations for central station, workstations, and controllers.

C. Product Schedules.

D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. UPS: Sizing calculations.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Microsoft Windows software documentation.
2. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard- copy submittal.
4. System installation and setup guides with data forms to plan and record options and setup decisions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Laser Printers: Three toner cassettes and one replacement drum unit.
2. Credential card blanks, ready for printing. Include enough credential cards for all

personnel to be enrolled at the site plus an extra 50 percent for future use.

3. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
   1. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.

B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NFPA 70, "National Electrical Code."

E. Comply with SIA DC-01, SIA DC-03 and SIA DC-07.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Central Station, Workstations, and Controllers:

   1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, noncondensing.
   2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.
   3. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
   4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.10 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

   1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
   2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-

controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

3. Indoor, Uncontrolled Environment: NEMA 250, Type 4 Type 12 enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Outdoor Environment: NEMA 250, NEMA 250, Type 4X enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. TBD

2.2 DESCRIPTION

A. Security Access System: PC-based central station, one or more networked PC-based workstations, and field-installed controllers, connected by a high-speed electronic-data transmission network.

B. System Software: Based on 64 bit, central-station, workstation operating system, server operating system, and application software. Software shall have the following capabilities:

1. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
2. Graphical user interface to show pull-down menus and a menu-tree format that complies with interface guidelines of Microsoft Windows.
3. System license for the entire system including capability for future additions that are within the indicated system size limits specified in this Section.
4. Open-architecture system that allows importing and exporting of data and interfacing with other systems that are compatible with Microsoft Windows.
5. Password-protected operator login and access.
6. Open-database-connectivity compliant.

C. Network connecting the central station and workstations shall be a LAN using Microsoft Windows-based TCP/IP with a capacity of connecting up to 99 workstations. System shall be portable across multiple communication platforms without changing system software.

D. Network(s) connecting PCs and controllers shall consist of one or more of the following:

1. Local area, IEEE 802.3 Fast Ethernet Gigabit-Ethernet, star topology network based on TCP/IP.
2. Direct-connected, RS-232 cable from the COM port of the central station to the first controller, then RS-485 cable to interconnect the remaining controllers at that Location.

2.3 OPERATION

A. Security access system shall use a single database for access-control and credential-creation functions.

B. Distributed Processing: A fully distributed processing system.
1. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
2. Intermediate controllers for access control are prohibited.
3. In the event that communications with the central controller are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the central station.

C. Number of Locations:

1. Support at least 32,000 separate Locations using a single PC with combinations of direct- connect, dial-up, or TCP/IP LAN connections to each Location.
2. Each Location shall have its own database and history in the central station.
3. Locations may be combined to share a common database.

D. Data Capacity:

1. 130 different card-reader formats.
2. 999 comments.
3. 48 graphic file types for importing maps.

E. Location Capacity:

1. 128 reader-controlled doors.
2. 50,000 total-access credentials.
3. 2048 supervised alarm inputs.
4. 2048 programmable outputs.
5. 32,000 custom action messages per Location to instruct operator on action required when alarm is received.

F. System Network Requirements:

1. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
2. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
3. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
4. Communications controller may be used as an interface between the central-station display systems and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.

G. Central station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central station shall control system networks to interconnect all system components, including workstations and field-installed controllers.

H. Field equipment shall include controllers, sensors, and controls.

1. Controllers shall serve as an interface between the central station and sensors and controls.
2. Data exchange between the central station and the controllers shall include down-line transmission of commands, software, and databases to controllers.
3. The up-line data exchange from the controller to the central station shall include status data such as intrusion alarms, status reports, and entry-control records.
4. Controllers are classified as alarm-annunciation or entry-control type.

I. System Response to Alarms:

1. Field device network shall provide a system end-to-end response time of one half second or less for every device connected to the system.
2. Alarms shall be annunciated at the central station within one second of the alarm occurring at a controller or at a device controlled by a local controller, and within 100 ms if the alarm occurs at the central station.
3. Alarm and status changes shall be displayed within 100 ms after receipt of data by the central station.
4. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within five seconds of alarm receipt at the security console.
5. This response time shall be maintained during system heavy load.

J. False-Alarm Reduction: The design of the central station and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.

K. Error Detection:

1. Use a cyclic code method to detect single- and double-bit errors, burst errors of eight bits or fewer, and at least 99 percent of all other multibit and burst errors

between controllers and the central station.
2. Interactive or product error-detection codes alone will not be acceptable.
3. A message shall be in error if one bit is received incorrectly.
4. Retransmit messages with detected errors.
5. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
6. Central station shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
7. Monitor the frequency of data transmission failure for display and logging.

L. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.

M. Door Hardware Interface:

1. Comply with requirements in Section 087100 "Door Hardware" for door hardware required to be monitored or controlled by the security access system.
2. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.

2.4 APPLICATION SOFTWARE

A. System Software: Based on 64-bit, Microsoft Windows central-station and workstation operating system and application software.

1. Multiuser multitasking shall allow independent activities and monitoring to occur simultaneously at different workstations.
2. Graphical user interface shall show pull-down menus and a menu-tree format.
3. Capability for future additions within the indicated system size limits.
4. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
5. Password-protected operator login and access.

B. Peer Computer Control Software: Detect a failure of a central computer and cause the other central computer to assume control of all system functions without interruption of operation. Both central computers shall have drivers to support this mode of operation.

C. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors and DTS links, operate displays, report alarms, generate reports, and help train system operators.

1. Reside at the central station, workstations, and controllers as required to perform specified functions.
2. Operate and manage peripheral devices.
3. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
4. Import custom icons into graphics to represent alarms and I/O devices.
5. Globally link I/O so that any I/O can link to any other I/O within the same Location

without requiring interaction with the host PC. This operation shall be at the controller.

6. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host PC. This operation shall be at the controller.
7. Messages from PC to controllers and controllers to controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
8. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other PC-to-controller communications methods by changing the polling frequency and the amount of time the system waits for a response.
9. Automatic and encrypted backups for database and history backups shall be automatically stored at the central-control PC and encrypted with a nine-character alphanumeric password that must be used to restore or read data contained in backup.
10. Operator audit trail for recording and reporting all changes made to database and system software.
11. Support network protocol and topology, TCP/IP, and LAN/WAN.

D. Workstation Software:

1. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
2. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.

E. Controller Software:

1. Controllers shall operate as autonomous, intelligent processing units.
   a. Controllers shall make decisions about access control, alarm monitoring, linking functions, and door-locking schedules for their operation, independent of other system components.
   b. Controllers shall be part of a fully distributed processing-control network.
   c. The portion of the database associated with a controller, and consisting of parameters, constraints, and the latest value or status of points connected to that controller, shall be maintained in the controller.

2. The following functions shall be fully implemented and operational within each controller:

   a. Monitoring inputs.
   b. Controlling outputs.
   c. Automatically reporting alarms to the central station.
   d. Reporting of sensor and output status to the central station on request.
   e. Maintaining real time, automatically updated by the central station at least once a day.

f. Communicating with the central station.
g. Executing controller resident programs.
h. Diagnosing.
i. Downloading and uploading data to and from the central station.

3. Controller Operations at a Location:

a. Unlimited number of controllers connected via the security LAN. Globally operating I/O linking and anti-passback functions between controllers within the same Location without central-station or workstation intervention. Linking and anti- passback shall remain fully functional within the same Location even when the central station or workstations are off-line.
b. In the event of communication failure between the central station and a Location, there shall be no degradation in operations at the controllers at that Location. Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.
c. Buffered events shall be handled in a first-in-first-out mode of operation.

4. Individual Controller Operation:

a. Controllers shall transmit alarms, status changes, and other data to the central station when communications circuits are operable. If communications are not available, controllers shall function in a stand-alone mode; operational data, including the status and alarm data normally transmitted to the central station, shall be stored for later transmission to the central station. Storage capacity for the latest 1024 events shall be provided at each controller.
b. Card-reader ports of a controller shall be custom configurable for at least 120 different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different controllers or within the same controller.
c. Controllers shall provide a response to card readers or keypad entries in less than
0.25 seconds, regardless of system size.
d. Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to their proper working state. This shall happen without any operator intervention.
e. Initial Startup: When controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each controller.
f. On failure for any reason, controllers shall perform an orderly shutdown and force controller outputs to a predetermined failure-mode state, consistent with the failure modes shown and the associated control device.
g. After power is restored, following a power failure, startup software shall initiate self- test diagnostic routines, after which controllers shall resume normal operation.
h. After controller failure, if the database and application software are no longer resident, controllers shall not restart but shall remain in the failure mode until repaired. If database and application programs are resident, controllers shall

immediately resume operation. If not, software shall be restored automatically from the central station.

5. Communications Monitoring:

   a. System shall monitor and report status of LAN health

6. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the central station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.

F. PC-to-Controller Communications:

1. Central-station or workstation communications shall use the following:

   a. Direct connection using serial ports of the PC.
   b. TCP/IP LAN interface cards.
   c. Dial-up or cable modems for connections to Locations.

2. Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem communications incoming only," or as an ASCII output port. Serial ports shall have adjustable data transmission rates and shall be selectable under program control.
3. Use multiport communications board if more than two serial ports are needed.

   a. Use a 4-, 8-, or 16-serial port configuration that is expandable to 32- or 64-serial ports.
   b. Connect the first board to an internal PCI bus adapter card.

4. Direct serial, TCP/IP, and dial-up, cable, or satellite communications shall be alike in the monitoring or control of the system except for the connection that must first be made to a dial-up or voice-over IP Location.
5. TCP/IP network interface card (NIV) shall have an option to set the poll-frequency and message-response time-out settings.
6. PC-to-controller and controller-to-controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications in this subparagraph shall be verified and buffered, and retransmitted if not acknowledged.

G. Direct Serial or TCP/IP PC-to-Controller Communications:
1. Communication software on the PC shall supervise the PC-to-controller communications link.
2. Loss of communications to any controller shall result in an alarm at all PCs running the communication software.
3. When communications are restored, all buffered events shall automatically upload to the PC, and any database changes shall be automatically sent to the controller.

H. Database Downloads:

1. All data transmissions from PCs to a Location, and between controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
2. If a controller is reset for any reason, it shall automatically request and receive a database download from the PC. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.

I. Operator Interface:

1. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
2. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
3. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
4. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
5. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
6. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:

    a. Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
    b. Maps to provide real-time display animation and allow for control of points assigned to them.
    c. System to allow inputs, outputs, and override groups to be placed on different maps.
    d. Software to allow changing the order or priority in which maps will be displayed.

7. Override Groups Containing I/Os:

    a. System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
    b. Icon shall change automatically to show the live summary status of points in that group.
    c. Override group icon shall provide a method to manually control or set to time-zone points in the group.
    d. Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.

8. Schedule Overrides of I/Os and Override Groups:

    a. To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.
    b. Each schedule shall be composed of a minimum of two dates with separate times for each date.
    c. The first time and date shall be assigned the override state that the point shall advance to when the time and date become current.
    d. The second time and date shall be assigned the state that the point shall return to when the time and date become current.

9. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.

J. Operator Access Control:

1. Control operator access to system controls through three password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
2. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
3. A minimum of 32 passwords shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.
4. The password shall not be displayed or printed.
5. Each password shall be definable and assignable for the following:

    a. Selected commands to be usable.
    b. Access to system software.
    c. Access to application software.
    d. Individual zones that are to be accessed.
    e. Access to database.

K. Operator Commands:

1. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
2. Command inputs shall be acknowledged and processing shall start in not less than one half second.
3. Tasks that are executed by operator's commands shall include the following:

    a. Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
    b. Place Zone in Access: Used to remotely disable intrusion-alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
    c. Place Zone in Secure: Used to remotely activate intrusion-alarm circuits

emanating from a specific zone.

d. System Test: Allows the operator to initiate a system-wide operational test.
e. Zone Test: Allows the operator to initiate an operational test for a specific zone.
f. Print reports.
g. Change Operator: Used for changing operators.
h. Security Lighting Controls: Allows the operator to remotely turn on or turn off security lights.
i. Display Graphics: Used to show any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
j. Run system tests.
k. Generate and format reports.
l. Request help with the system operation.

1) Include in main menus.
2) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
3) Provide navigation to specific topic from within the first help window.
4) Help shall be accessible outside the application program.

m. Entry-Control Commands:

1) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
2) Arm or disarm each monitored input up to four times a day through time- zone programming.
3) Enable or disable readers or keypads up to two times a day through time- zone programming.
4) Enable or disable cards or codes up to four times a day per entry point through access-level programming.

4. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:

a. Command entered is incorrect or incomplete.
b. Operator is restricted from using that command.
c. Command addresses a point that is disabled or out of service.
d. Command addresses a point that does not exist.

L. Alarms

Command is outside the system's capacity.

1. System Setup:

a. Assign manual and automatic responses to incoming-point status change or alarms.

b. Automatically respond to input with a link to other inputs, outputs, or operator- response plans; unique sound with use of WAV files; and maps or images that graphically represent the point location.
c. Sixty-character message field for each alarm.
d. Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages to selectable alarm originating device.
e. Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
f. Allow 25 secondary messages with a field of four lines of 60 characters each.
g. Store the most recent 1000 alarms for recall by the operator using the report generator.

2. Software Tamper:

a. Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
b. Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond the authorization level.
c. Maintain a transcript file of the last 5000 commands entered at each central station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
d. Allow only acknowledgment of software tamper alarms.

3. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
4. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
5. Multimedia Alarm Annunciation: WAV files to be associated with alarm events for audio annunciation or instructions.
6. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.
7. Alarm Automation Interface: High-level interface to central-station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in the same manner as burglar alarms, using a serial interface.
8. Surveillance Alarm Interface: Allow commands to be sent to surveillance systems during alarms (or input change of state) through serial ports.
9. Camera Control: Provides operator ability to select and control cameras from graphic maps.

M. Alarm Monitoring: Monitor sensors, controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display

the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.

1. Displayed alarm data shall include type of alarm, location of alarm, and secondary alarm messages.
2. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
3. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.
4. Alarms initiate a status of "pending" and require the following two handling steps by operators:
    a. First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un- Resolved."
    b. Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.
5. Each workstation shall display the total pending alarms and total unresolved alarms.
6. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
7. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
8. Alarms shall be displayed and managed from a minimum of four different windows.
    a. Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.
    b. History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
    c. Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
    d. Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.
9. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
10. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
11. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
12. Identical alarms from the same alarm point shall be acknowledged at the same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
13. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.

14. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.

N. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.

1. Color Code:

a. FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
b. STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
c. YELLOW: Advises operator that a zone is in access.
d. MUTED or NO COLOR: Indicates that a zone is secure and that power is on.

2. Graphics:
a. Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
b. Allow I/O to be placed on graphic maps by the drag-and-drop method.
c. Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on the graphic map.
d. Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic maps associated with I/Os.
e. Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
f. Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.
g. Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.

O. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.

1. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.

P. Report-Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest-priority activity. Report-generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.

1. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of the period; and the default printer.
2. Printing on Request: An operator may request a printout of any report.

3. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm such as door alarm, intrusion alarm, tamper alarm, etc., the type of sensor, the location, the time, and the action taken.
4. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
5. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
6. Automatic History Reports: Named, saved, and scheduled for automatic generation.
7. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
8. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
9. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
10. Who Is "In" (Muster) Report:

    a. Emergency Muster Report: One-click operation on toolbar launches report.
    b. Cardholder Report. Contain a count of persons who are "In" at a selected Location and a detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.
11. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that data are available on-site at all times.
12. Activity and Alarm On-Line Printing: Activity printers for use at workstations; prints all events, or alarms only.
13. History Reports: Custom reports that allow the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.

    a. Initially store history on the hard disk of the host PC.
    b. Permit viewing of the history on workstations or print history to any system printer.
    c. The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
    d. Each report shall depict the date, time, event type, event description, and device; or I/O name, cardholder group assignment, and cardholder name or code number.
    e. Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
    f. Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.

14. Reports shall have the following four options:

a. View on screen.
b. Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to the system.
c. "Save to File" with full path statement.
d. System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.

15. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:

a. Active, inactive, or future activate or deactivate.
b. Code number, name, or imprinted card number.
c. Group, Location access levels.
d. Start and stop code range.
e. Codes that have not been used since a selectable number of days.
f. In, out, or either status.
g. Codes with trace designation.

16. The reports of system database shall allow options so that every data field may be printed.
17. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.

Q. Anti-Passback:

1. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.
2. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.
3. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.
4. Timed Anti-Passback: A controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
5. Provide four separate zones per Location that can operate without requiring interaction with the host PC (done at controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as "Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.
6. The anti-passback schemes shall be definable for each individual door.
7. The Master Access Level shall override anti-passback.
8. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential-holder population anti-passback status to a neutral status.

R. Visitor Assignment:

1. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only those access levels that have been designated as approved for visitors.
2. Provide an automated log of visitor name, time and doors accessed, and name of person contacted.
3. Allow a visitor designation to be assigned to a credential holder.
4. Security access system shall be able to restrict the access levels that may be assigned to credentials issued to visitors.
5. Allow operator to recall visitors' credential-holder file once a visitor is enrolled in the system.
6. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
7. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.

S. Time and Attendance:

1. Time and attendance reporting shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
2. Shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
3. System software setup shall allow designation of selected access-control readers as time and attendance hardware to gather the clock-in and clock-out times of the users at these readers.

    a. Reports shall show in and out times for each day, total time in for each day, and a total time in for period specified by the user.
    b. Allow the operator to view and print the reports, or save the reports to a file.
    c. Alphabetically sort reports on the person's last name, by Location or location group. Include all credential holders or optionally select individual credential holders for the report.

T. Training Software: Enables operators to practice system operation, including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.

U. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.

1. The enrollment station shall not have alarm response or acknowledgment functions.
2. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
3. The program shall provide means to disable the enrollment station when it is unattended, to prevent unauthorized use.
4. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of

personnel identity- verification subsystems, this shall include biometric data. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.

5. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:

    a. MASK: Determines a specific format with which data must comply.
    b. REQUIRED: Operator is required to enter data into field before saving.
    c. UNIQUE: Data entered must be unique.
    d. DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
    e. NAME ID: Data entered will be considered a unique ID for the cardholder.

6. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.
7. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.
8. Batch card printing.
9. Default card data can be programmed to speed data entry for sites where most card data are similar.
10. Enhanced File Import Utility: Allows the importing of cardholder data and images.
11. Card Expire Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.

2.5 SYSTEM DATABASE

A. Database and database management software shall define and modify each point in database using operator commands. Definition shall include parameters and constraints associated with each system device.

B. Database Operations:
    1. System data management shall be in a hierarchical menu-tree format, with navigation through expandable menu branches and manipulated with use of menus and icons in a main menu and system toolbar.
    2. Navigational Aids:

        a. Toolbar icons for add, delete, copy, print, capture image, activate, deactivate, and muster report.
        b. Point and click feature to facilitate data manipulation.
        c. Next and previous command buttons visible when editing database fields to facilitate navigation from one record to the next.
        d. Copy command and copy tool in the toolbar to copy data from one record to create a new similar record.

3. Data entry shall be automatically checked for duplicate and illegal data and shall be verified for valid format.
4. System shall generate a memo or note field for each item that is stored in database, allowing the storing of information about any defining characteristics of the item. Memo field is used for noting the purpose for which the item was entered, reasons for changes that were made, and the like.

C. File Management:

1. File management shall include database backup and restoration system, allowing selection of storage media, including external USB drives, and designated network resources.
2. Operations shall be both manual and automatic modes. The number of automatic sequential backups before the oldest backup will be overwritten; FIFO mode shall be operator selectable.
3. Backup program shall provide manual operation from any PC on the LAN and shall operate while system remains operational.

D. Operator Passwords:

1. Support up to 32,000 individual system operators, each with a unique password.
2. 4 to 12 alphanumeric characters.
3. Allow passwords to be case sensitive.
4. Passwords shall not be displayed when entered.
5. Passwords shall have unique and customizable password profile, and allow several operators to share a password profile. Include the following features in the password profile:

    a. Predetermine the highest-level password profile for access to all functions and areas of program.
    b. Allow or disallow operator access to any program operation, including the functions of View, Add, Edit, and Delete.
    c. Restrict doors to which an operator can assign access.

6. Operators shall use a user name and password to log on to system. This user name and password shall be used to access database areas and programs as determined by the associated profile.
7. Make provision to allow the operator to log off without fully exiting program. User may be logged off but program will remain running while displaying the login window for the next operator.

E. Access Card/Code Operation and Management: Access authorization shall be by card, by a manually entered code (PIN), or by a combination of both (card plus PIN).

1. Access authorization shall verify the facility code first, the card or card-and-PIN validation second, and the access level (time of day, day of week, date), anti-passback status, and number of uses last.
2. Use data-entry windows to view, edit, and issue access levels. Access-authorization entry-management system shall maintain and coordinate all access levels to prevent duplication or the incorrect creation of levels.
3. Allow assignment of multiple cards/codes to a cardholder.

4. Allow assignment of up to four access levels for each Location to a cardholder. Each access level may contain any combination of doors.
5. Each door may be assigned four time zones.
6. Access codes may be up to 11 digits in length.
7. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
8. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
9. Cardholder Tracing: Allow for selection of cardholder for tracing. Make a special audible and visible annunciation at control station when a selected card or code is used at a designated code reader. Annunciation shall include an automatic display of the cardholder image.
10. Allow each cardholder to be given either an unlimited number of uses or a number from one to 9999 that regulates the number of times the card can be used before it is automatically deactivated.
11. Provide for cards and codes to be activated and deactivated manually or automatically by date. Provide for multiple deactivate dates to be preprogrammed.

F. Security Access Integration:

1. Photo ID badging and photo verification shall use the same database as the security access and may query data from cardholder, group, and other personal information to build a custom ID badge.
2. Automatic or manual image recall and manual access based on photo verification shall also be a means of access verification and entry.
3. System shall allow sorting of cardholders together by group or other characteristic for a fast and efficient method of reporting on, and enabling or disabling, cards or codes.
4. Access control system relay output shall be configured as a PLC input to the Detention Monitoring and Control system. The PLC will see the input as a request to exit and provided there are no conditional denials of access, the PLC will fire the door relay unlocking the lock. The access control system will not control the lock directly.

G. Key control and tracking shall be an integrated function of cardholder data.

1. Provide the ability to store information about which conventional metal keys are issued and to whom, along with key construction information.
2. Reports shall be designed to list everyone who possesses a specified key.

H. Facility Codes: System shall accommodate up to 2048 facility codes per Location, with the option of allowing facility codes to work at all doors or only at particular doors.

I. Operator Comments:
1. With the press of one appropriate button on the toolbar, the user shall be permitted to enter operator comments into the history at any time.
2. Automatic prompting of operator comment shall occur before the resolution of each alarm.
3. Operator comments shall be recorded by time, date, and operator number.
4. Comments shall be sorted and viewed through reports and history.

5. The operator may enter comments in two ways; either or both may be used:

    a. Manually entered through keyboard data entry (typed), up to 65,000 characters per each alarm.
    b. Predefined and stored in database for retrieval on request.

6. System shall have a minimum of 999 predefined operator comments with up to 30 characters per comment.

J. Group:

1. Group names may be used to sort cardholders into groups that allow the operator to determine the tenant, vendor, contractor, department, division, or any other designation of a group to which the person belongs.
2. System software shall have the capacity to assign one of 32,000 group names to an access authorization.
3. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
4. Allow sorting of history reports and code list printouts by group name.

K. Time Zones:

1. Each zone consists of a start and stop time for seven days of the week and three holiday schedules. A time zone is assigned to inputs, outputs, or access levels to determine when an input shall automatically arm or disarm, when an output automatically opens or secures, or when access authorization assigned to an access level will be denied or granted.
2. Up to four time zones may be assigned to inputs and outputs to allow up to four arm or disarm periods per day or four lock or unlock periods per day; up to three holiday override schedules may be assigned to a time zone.
3. Data-entry window shall display a dynamically linked bar graph showing active and inactive times for each day and holiday, as start and stop times are entered or edited.
4. System shall have the capacity for 2048 time zones for each Location.

L. Holidays:

1. Three different holiday schedules may be assigned to a time zone. Holiday schedule consists of date in format MM/DD/YYYY and a description. When the holiday date matches the current date of the time zone, the holiday schedule replaces the time-zone schedule for that 24-hour period.
2. System shall have the capacity for 32,000 holidays.
3. Three separate holiday schedules may be applied to a time zone.
4. Holidays have an option to be designated as occurring on the designated date each year. These holidays remain in the system and will not be purged.
5. Holidays not designated to occur each year shall be automatically purged from the database after the date expires.

M. Access Levels:

1. System shall allow for the creation of up to 32,000 access levels.

2. One level shall be predefined as the Master Access Level. The Master Access Level shall work at all doors at all times and override any anti-passback.
3. System shall allow for access to be restricted to any area by reader and by time. Access levels shall determine when and where an Identifier is authorized.
4. System shall be able to create multiple door and time-zone combinations under the same access level so that an Identifier may be valid during different time periods at different readers even if the readers are on the same controller.

N. User-Defined Fields:

1. System shall provide a minimum of 99 user-defined fields, each with up to 50 characters, for specific information about each credential holder.
2. System shall accommodate a title for each field; field length shall be 20 characters.
3. A "Required" option may be applied to each user-defined field that, when selected, forces the operator to enter data in the user-defined field before the credential can be saved.
4. A "Unique" option may be applied to each user-defined field that, when selected, will not allow duplicate data from different credential holders to be entered.
5. Data format option may be assigned to each user-defined field that will require the data to be entered with certain character types in specific spots in the field entry window.
6. A user-defined field, if selected, will define the field as a deactivate date. The selection shall automatically cause the data to be formatted with the windows MM/DD/YYYY date format. The credential of the holder will be deactivated on that date.
7. A search function shall allow any one user-defined field or combination of user-defined fields to be searched to find the appropriate cardholder. The search function shall include a search for a character string.
8. System shall have the ability to print cardholders based on and organized by the user- defined fields.

O. Code Tracing:

1. System shall perform code tracing selectable by cardholder and by reader.
2. Any code may be designated as a "traced code" with no limit to how many codes can be traced.
3. Any reader may be designated as a "trace reader" with no limit to which or how many readers can be used for code tracing.
4. When a traced code is used at a trace reader, the access-granted message that usually appears on the monitor window of the central station shall be highlighted with a different color than regular messages. A short singular beep shall occur at the same time the highlighted message is displayed on the window.
5. The traced cardholder image (if image exists) shall appear on workstations when used at a trace reader.

2.6 SURGE AND TAMPER PROTECTION

A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or

sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.

1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low- Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.

B. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

2.7 CENTRAL-STATION HARDWARE

A. Central-Station Computer: Standard unmodified PC of modular design. The CPU word size shall be 64 bytes or larger; the CPU operating speed shall be at least 4 GHz.

1. Memory: 8 GB of usable installed memory, expandable to a minimum of 64 GB without additional chassis or power supplies.
2. Power Supply: Minimum capacity of 400 W.
3. Serial Ports: Provide 4 USB 3.0 serial ports one the front and 3 on the read of the chassis,
4. 1 SD Card Reader
5. LAN Adapter Card: 1000BaseT IEEE 802.3 Ethernet adapter.
6. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
7. Color Monitor: Not less than 20 inches, with a minimum resolution of 2560 x 1440 native resolution. The video card shall support at least 16.7 million colors at native resolution
8. Keyboard: With a minimum of 104 key USB interface
9. Mouse: Standard, USB interface.
10. Special-function keyboard attachments or special-function keys to facilitate data input of the following operator tasks:

    a. Help.
    b. Alarm Acknowledge.
    c. Place Zone in Access.
    d. Place Zone in Secure.
    e. System Test.
    f. Print Reports.
    g. Change Operator.

11. Disk storage shall include the following, each with appropriate controller:

    a. Minimum 1 TB internal HDD
    b. DVD-RW Optical Drive.

2.8 STANDARD WORKSTATION HARDWARE

A. Central-Station Computer: Standard unmodified PC of modular design. The CPU word size shall be 64 bytes or larger; the CPU operating speed shall be at least 4 GHz.
   1. Memory: 8 GB of usable installed memory, expandable to a minimum of 64 GB without additional chassis or power supplies.
   2. Power Supply: Minimum capacity of 400 W.
   3. Serial Ports: Provide 4 USB 3.0 serial ports one the front and 3 on the read of the chassis,
   4. 1 SD Card Reader
   5. LAN Adapter Card: 1000BaseT IEEE 802.3 Ethernet adapter.
   6. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
   7. Color Monitor: Not less than 20 inches, with a minimum resolution of 2560 x 1440 native resolution. The video card shall support at least 16.7 million colors at native resolution
   8. Keyboard: With a minimum of 104 key USB interface
   9. Mouse: Standard, USB interface.
   10. Special-function keyboard attachments or special-function keys to facilitate data input of the following operator tasks:
      a. Help.
      b. Alarm Acknowledge.
      c. Place Zone in Access.
      d. Place Zone in Secure.
      e. System Test.
      f. Print Reports.
      g. Change Operator.
   11. Disk storage shall include the following, each with appropriate controller:
      a. Minimum 1 TB internal HDD
      b. DVD-RW Optical Drive.

2.9 COMMUNICATIONS WORKSTATION

A. Central-Station Computer: Standard unmodified PC of modular design. The CPU word size shall be 64 bytes or larger; the CPU operating speed shall be at least 4 GHz.
   1. Memory: 8 GB of usable installed memory, expandable to a minimum of 64 GB without additional chassis or power supplies.
   2. Power Supply: Minimum capacity of 400 W.
   3. Serial Ports: Provide 4 USB 3.0 serial ports one the front and 3 on the read of the chassis,
   4. 1 SD Card Reader
   5. LAN Adapter Card: 1000BaseT IEEE 802.3 Ethernet adapter.

6. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
7. Color Monitor: Not less than 20 inches, with a minimum resolution of 2560 x 1440 native resolution. The video card shall support at least 16.7 million colors at native resolution
8. Keyboard: With a minimum of 104 key USB interface
9. Mouse: Standard, USB interface.
10. Special-function keyboard attachments or special-function keys to facilitate data input of the following operator tasks:

    a. Help.
    b. Alarm Acknowledge.
    c. Place Zone in Access.
    d. Place Zone in Secure.
    e. System Test.
    f. Print Reports.
    g. Change Operator.

11. Disk storage shall include the following, each with appropriate controller:

    a. Minimum 1 TB internal HDD
    b. DVD-RW Optical Drive.

2.10 CONTROLLERS

A. Controllers: Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the central station or workstation for controlling its operation.

B. Subject to compliance with requirements in this article, manufacturers may use multipurpose controllers.

C. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.

D. Alarm Annunciation Controller:

1. The controller shall automatically restore communication within 10 seconds after an interruption with the field device network provide line supervision of all discrete monitor point circuits.

    a. Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
    b. Alarm-Line Supervision:

        1) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal and for open, grounded, or shorted conditions using dc change measurements.

2) Transmit alarm-line-supervision alarm to the central station during the next interrogation cycle after the abnormal current condition.

c. Outputs: Managed by central-station software.

2. Auxiliary Equipment Power: A GFI service outlet inside the controller enclosure.

E. Entry-Control Controller:

1. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, biometric personnel identity-verification devices, door strikes, magnetic latches, gate and door operators, and exit push buttons.
   a. Operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the controller and the field-device network.
   b. Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:

      1) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
      2) Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control.

   c. Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.

2. Inputs:

   a. Data from entry-control devices; use this input to change modes between access and secure.
   b. Database downloads and updates from the central station that include enrollment and privilege information.

3. Outputs:

   a. Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
   b. Grant or deny entry by sending control signals to portal-control devices include alarm shunt timed to allow entry/exit.
   c. Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the central station.
   d. Door Prop Alarm: If a portal is held open for longer than 20 seconds an alarm condition shall be generated.

4. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.
5. Data Line Problems: For periods of loss of communication with the central station, or when data transmission is degraded and generating continuous checksum errors, the controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.

    a. Store transactions during periods of communication loss between the controller and access-control devices for subsequent upload to the central station on restoration of communication.

6. Controller Power: NFPA 70, Class II power-supply transformer, with 12- or 24-V ac secondary, backup battery and charger.

    a. Backup Battery: rechargeable sealed lead acid; with a full one-year warranty. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
    b. Backup Power-Supply Capacity: 20 minutes of battery supply. Submit battery and charger calculations.
    c. Power Monitoring: Provide manual, dynamic battery-load test, initiated and monitored at the control center; with automatic disconnection of the controller when battery voltage drops below controller limits. Report by using local controller- mounted digital displays and by communicating status to central station. Indicate normal power on and battery charger on trickle charge. Indicate and report the following:

        1) Trouble Alarm: Normal power-off load assumed by battery.
        2) Trouble Alarm: Low battery.
        3) Alarm: Power off.

2.11 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

A. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.

B. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.

C. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:

1. Indoors, controlled environment.
2. Indoors, uncontrolled environment.
3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.

D. Display: Digital visual indicator shall provide visible and audible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.

E. Proximity Readers:

1. Active-detection 13.56MHz high frequency iClass SEOS standard proximity card readers shall provide power to compatible credential cards.
2. The card reader shall read proximity cards in a range from direct contact to at least 3 inches from the reader.

F. Communication Protocol: Compatible with local processor.

G. Proximity Reader: The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.

H. Credential Card Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.

I. Card Size and Dimensional Stability: Credential cards shall be 2-1/8 by 3-3/8 inches. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.

J. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.

K. Card Construction:

1. Composite 40% Polyester/PVC construction.
2. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
3. Incorporate holographic images as a security enhancement.
4. Furnish equipment for on-site assembly and lamination of credential cards.

L. Card Quantity:

1. Provide 100 cards

2.12 ENROLLMENT CENTER

IUH PD at the AAHC will create all badging and users will be imported to the CUP system.

2.13 PUSH-BUTTON SWITCHES

A. Securitron

B. Locknetics

C. FAS

D. Push-Button Switches: Momentary-contact back-lighted push buttons with stainless-steel switch enclosures.

E. Electrical Ratings:

1. Minimum continuous current rating of 10A at 120-VAC or 5A at 240-VAC.
2. SPST momentary contacts.

F. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.

G. Enclosures shall additionally be suitable for installation in the following locations:

1. Indoors, controlled environment.
2. Indoors, uncontrolled environment.
3. Outdoors.

H. Power: Push-button switches shall be powered from their associated controller, using dc control.

2.14 FIELD-PROCESSING SOFTWARE

A. Operating System:

1. Local processors shall contain an operating system that controls and schedules that local processor's activities in real time.

2. Local processor shall maintain a point database in its memory that includes parameters, constraints, and the latest value or status of all points connected to that local processor.
3. Execution of local processor application programs shall utilize the data in memory resident files.
4. Operating system shall include a real-time clock function that maintains the seconds, minutes, hours, date, and month, including day of the week.

B. Startup Software:

1. Causes automatic commencement of operation without human intervention, including startup of all connected I/O functions.
2. Local processor restart program based on detection of power failure at the local processor shall be included in the local processor software.
3. Initiates operation of self-test diagnostic routines.
4. Upon failure of the local processor, if the database and application software are no longer resident, the local processor shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made.
5. If the database and application programs are resident, the local processor shall immediately resume operation.

C. Operating Mode:

1. Local processors shall control and monitor inputs and outputs as specified, independent of communications with the central station or designated workstations.
2. Alarms, status changes, and other data shall be transmitted to the central station or designated workstations when communications circuits are operable.
3. If communications are not available, each local processor shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the central station or designated workstations, shall be stored for later transmission to the central station or designated workstations.
4. Storage for the latest 4000 events shall be provided at local processors, as a minimum.
5. Local processors shall accept software downloaded from the central station.
6. Panel shall support on board memory to accomplish firmware downloads from a central location.

D. Failure Mode: Upon failure for any reason, each local processor shall perform an orderly shutdown and force all local processor outputs to a predetermined (failure-mode) state, consistent with the failure modes shown and the associated control device.

E. Functions:

1. Monitoring of inputs.
2. Control of outputs.
3. Reporting of alarms automatically to the central station.
4. Reporting of sensor and output status to central station upon request.
5. Maintenance of real time, automatically updated by the central station at least once a day.
6. Communication with the central station.
7. Execution of local processor resident programs.
8. Diagnostics.

9. Download and upload data to and from the central station.

2.15 FIELD-PROCESSING HARDWARE

A. Alarm Annunciation Local Processor:

1. Respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
3. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
4. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
5. Local processor shall report line supervision alarms to the central station.
6. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 milliseconds.
7. Alarm condition shall be transmitted to the central computer during the next interrogation cycle.
8. Local processor outputs shall reflect the state of commands issued by the central station.
9. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
10. Local processor shall have at least four command outputs.
11. Local processor shall be able to communicate with the central station via TCP/IP as a minimum.

B. Processor Power Supply:

1. Local processor and sensors shall be powered from an uninterruptible power source.
2. Uninterruptible power source shall provide 20 minutes of battery back-up power in the event of primary power failure and shall automatically fully recharge the batteries within 12 hours after primary power is restored.
3. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.
4. Batteries shall be sealed, non-outgassing type.
5. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.
6. Loss of primary power shall be reported to the central station as an alarm.

C. Auxiliary Equipment Power: A GFI service outlet shall be furnished inside the local processor's enclosure.

D. Entry-Control Local Processor:

1. Entry-control local processor shall respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
3. Entry-control local processor shall provide local entry-control functions including communicating with field devices such as card readers, keypads, biometric personnel identity-verification devices, door strikes, magnetic latches, gate and door operators, and exit push buttons.
4. Processor shall also accept data from entry-control field devices as well as database downloads and updates from the central station that include enrollment and privilege information.
5. Processor shall send indications of successful or failed attempts to use entry-control field devices and shall make comparisons of presented information with stored identification information.
6. Processor shall grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
7. Entry-control local processor shall use inputs from entry-control devices to change modes between access and secure.
8. Local processor shall maintain a date-time- and location-stamped record of each transaction and transmit transaction records to the central station.
9. Processor shall operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the local processor and the central station.
10. Processor shall store a minimum of 4000 transactions during periods of communication loss between the local processor and the central station for subsequent upload to the central station upon restoration of communication.
11. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
12. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
13. Local processor shall report line supervision alarms to the central station.
14. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 ms.
15. Alarm condition shall be transmitted to the central station during the next interrogation cycle.
16. Entry-control local processor shall include the necessary software drivers to communicate with entry-control field devices. Information generated by the entry-control field devices shall be accepted by the local processor and automatically processed to determine valid identification of the individual present at the portal.
17. Upon authentication of the credentials or information presented, the local processor shall automatically check privileges of the identified individual, allowing only those actions granted as privileges.
18. Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control. The local processor shall maintain

a date-time- and location-stamped record of each transaction.

19. Transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
20. Local processor outputs shall reflect the state of commands issued by the central station.
21. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
22. Local processor shall have at least four addressable outputs.
23. The entry-control local processor shall also provide control outputs to portal-control devices.
24. Local processor shall be able to communicate with the central station via TCP/IP as a minimum.

2.16 TRANSFORMERS

A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
B. Examine rough-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Comply with recommendations in SIA CP-01.

B. Comply with TIA/EIA 606-A, "Administration Standard for Commercial Telecommunications Infrastructure."

C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.

1. Record setup data for control station and workstations.
2. For each Location, record setup of controller features and access requirements.
3. Propose start and stop times for time zones and holidays, and match up access levels for doors.

4. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
5. Assign action message names and compose messages.
6. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
7. Prepare and install alarm graphic maps.
8. Develop user-defined fields.
9. Develop screen layout formats.
10. Propose setups for guard tours and key control.
11. Discuss badge layout options; design badges.
12. Complete system diagnostics and operation verification.
13. Prepare a specific plan for system testing, startup, and demonstration.
14. Develop acceptance test concept and, on approval, develop specifics of the test.
15. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format.

D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 CABLING

A. Comply with NECA 1, "Good Workmanship in Electrical Construction."

B. Install cables and wiring according to requirements in Section 280513 "Conductors and Cables for Electronic Safety and Security."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Install LAN cables using techniques, practices, and methods that are consistent with Category rating of components and fiber-optic rating of components, and that ensure Category and fiber-optic performance of completed and linked signal paths, end to end.

F. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.

G. Install end-of-line resistors at the field device location and not at the controller or panel location.

3.4 CABLE APPLICATION

A. Comply with TIA 569-B, "Commercial Building Standard for Telecommunications Pathways and Spaces."

B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.

C. Card Readers and Keypads:

1. Install number of conductor pairs recommended by manufacturer for the functions specified.
2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft., and install No. 20 AWG wire if maximum distance is 500 ft.
3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.

D. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 250 ft.

E. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft.

3.5 GROUNDING

A. Comply with Section 270526 "Grounding and Bonding for communication syste.."

B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."

C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Bond shields and drain conductors to ground at only one point in each circuit.

E. Signal Ground:

1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
2. Bus: Mount on wall of main equipment room with standoff insulators.
3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.6 INSTALLATION

A. Push Buttons: Where multiple push buttons are housed within a single switch enclosure, they shall be stacked vertically with each push-button switch labeled with 1/4-inch-high

text and symbols as required. Push-button switches shall be connected to the controller associated with the portal to which they are applied, and shall operate the appropriate electric strike, electric bolt, or other facility release device.

B. Install card readers, and push buttons.

3.7 IDENTIFICATION

A. In addition to requirements in this article, comply with applicable requirements in Section 260553 "Identification for Electrical Systems" and with TIA/EIA 606-A.

B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.

C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

D. At completion, cable and asset management software shall reflect as-built conditions.

3.8 SYSTEM SOFTWARE AND HARDWARE

A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, UTP tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA 568-B.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA 568-B.1.
2. Test each circuit and component of each system. Tests shall include, but are not

limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.

3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

C. Devices and circuits will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

3.11 PROTECTION

A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured with an activated burglar alarm and access-control system reporting to a central station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 017900 "Demonstration and Training."

B. Develop separate training modules for the following:

1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
3. Security personnel.
4. Hardware maintenance personnel.
5. Corporate management.

END OF SECTION 281300

SECTION 282300 - VIDEO SURVEILLANCE FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Video Surveillance Cameras
2. Video Management System
3. Video Management Display Work Stations
4. Video Management System Software and Programming
5. Integration of the Video Management System with Access Control System, PLC/GUI System and other major subsystems as described herein
6. Ethernet LAN specifically for the video management system.

B. Video surveillance system shall be integrated with other systems as specified in: Section 281300 "Access Control System for Electronic Safety and Security," which specifies systems integration.

1.3 DEFINITIONS

A. ACS: Access Control System

B. CPU: Central Processing Unit

C. GUI: Graphical User Interface

D. I/O: Input/Output.

E. LAN: Local Area Network.

F. PC: Personal computer. Applies to the central station, workstations, and file servers.

G. PLC: Programmable Logic Controller

H. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

I. UPS: Uninterruptible power supply.

J. USB: Universal serial bus.

K. WAN: Wide area network.

L. WAV: The digital audio format used in Microsoft Windows.

M. WMP: Windows media player.

N. Windows: Operating system by Microsoft Corporation.

O. Workstation: A PC with software that is configured for specific, limited security-system functions.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
4. UPS: Sizing calculations.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Design Data: Include an equipment list consisting of every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.

1.6 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for cameras, camera-supporting equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

C. Product Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Laser Printers: Three toner cassettes and one replacement drum unit.
2. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 50 percent for future use.
3. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.9 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NECA 1.

C. Comply with NFPA 70.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Central Station, Workstations, and Controllers:

1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, noncondensing.
2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.
3. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.11 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. VMS Work Stations, LAN, SAN, servers and peripheral devices: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, Type 4 Type 12 enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Outdoor Environment: NEMA 250, NEMA 250, Type 4X enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: For system components subjected to corrosive fumes,

vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 12 months from date of final completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.

1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low- Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.

2.2 FIXED SURVEILLANCE CAMERA “A”

A. Manufacturers:

1. Hanwha Techwin QNV-8080R
2. Avigilon
3. Axis

B. Camera:

1. Max. 5 Megapixel (2592 x 1944) resolution
2. 3.2~10mm(3.1x) motorized varifocal lens
3. 0.15Lux (Color), 0Lux (B/W, IR LED on)
4. Max. 30fps@5MP (H.265 / H.264)
5. H.265, H.264, MJPEG codec support, Multiple streaming
6. Day & Night, WDR (120dB)
7. Tampering, Motion detection, Defocus detection
8. Micro SD / SDHC / SDXC memory slot (Max. 128GB)
9. Hallway view, WiseStream II support
10. IR Viewable length 30m
11. IP66, IK10, PoE

2.3 FIXED SURVEILLANCE CAMERA “B”

A. Manufacturers:

1. Hanwha Techwin QNV-6082R
2. Avigilon
3. Axis

B. Camera:

1. 2 Megapixel (1920 x 1080) resolution
2. 3.2 ~ 10mm (3.1x) varifocal lens
3. 30fps@all resolutions (H.265/H.264)
4. H.265, H.264, MJPEG codec supported, Multiple streaming
5. Day & Night (ICR), WDR (120dB)
6. Defocus detection, Directional detection, Motion detection, Enter/Exit, Tampering, Virtual line
7. micro SD (128GB) memory slot, PoE / 12V DC
8. IR viewable length 30m, IP66, IK10
9. LDC support (Lens Distortion Correction)

2.4 MULTI-IMAGER CAMERA “C”

A. Manufacturers:

1. Hanwha Techwin PNM-9085 RQZ1

B. Camera:

1. 4ea x 2560 x 1920 resolution (Max. 20MP)
2. 4ea x 3.6 ~ 9.4mm (2.6x) motorized varifocal lens
3. 4ea x Max. 30fps@5M (H.265, H.264)
4. Digital Image Stabilization with Built-in Gyro Sensor

5. H.265, H.264, MJPEG Codec Supported
6. Day & Night (ICR), WDR (120dB)
7. Motion detection, Tampering
8. Advanced Video Analytics
9. SD / SDHC / SDXC Memory slot
10. Remote adjustment of individual lenses

2.5 32" MONITOR

A. Manufacturers:

1. LG
2. Samsung
3. Approved Equal

B. Monitor

1. The HD monitor shall support up to 1920 x 1080 full HD resolution.
2. The HD monitor shall offer an LED backlight panel.
3. The HD monitor shall include the following inputs: an analog RGB, a digital DVI-D, a Y/C (S-video), a loop-through video, a digital HDMI, and one BNC.
4. The HD monitor shall have a maximum contrast ratio of 3,000:1.
5. The HD monitor shall include the Trigger and Auto Switch features.
6. The HD monitor shall be capable of being mounted to a wall.
7. The HD monitor shall include a remote control device.
8. The HD monitor shall support monitor wall applications.

2.6 VIDEO MANAGEMENT SYSTEM SOFTWARE

A. Manufacturers:

1. TBD

B. Software

1. Enterprise-Class Client/Server based video management system.
2. Operating System: Windows 10 (Owner requires latest version)
3. The NVMS shall provide the capability to configure and manage alarms and events.

a) Individual alarms from a third party system (access control, etc.) can be pre- selected and configured to be monitored.
b) Can define alarm events and triggers.
c) Can configure resulting video operations.
d) Detect if the video or audio signal is lost. And alert the system administrator.

e) Support receiving SNMP messages from servers and alert users.
f) Alarm and event notifications can be customized and forwarded to:

1) Users logged into the client application
2) Users logged into the mobile application
3) Configured email addresses
4) External entities and third party software, such as central monitoring stations and call centers

g) Can escalate alarms from one user or group to another if the alarm is unacknowledged for a preset duration.
h) Email notifications can be configured to:

1) Notify users and system administrators when an event or system health error occurs
2) Schedule when email notifications are sent
3) Include camera images in email notifications

i) Support receiving digital input triggers and triggering digital outputs from:

1) An input/output board
2) Supported IP camera or encoder
3) Integrated system

4. The NVMS shall provide the ability to send central monitoring stations heartbeat messages, or regular notification to confirm the system connection and that there are no events of note.
5. The NVMS shall maintain an event log and allow users to use the log events as triggers for specific event actions. Logged events include:

a) Server Events
b) Device Events
c) User Events
d) Alarm Events

6. The NVMS shall have the ability to assign actions in response to specific event triggers. Response actions include:

a) User Notification Actions
b) Monitoring Actions
c) Device Actions
d) PTZ Actions
e) Alarm Actions

7. The NVMS shall support conditional event triggers based on the selected digital input status.
8. The NVMS shall monitor events and alarms based on a user configurable schedule.
9. The NVMS shall provide a maintenance log and audit trail of all system errors and events.
10. The NVMS shall support software level integration with third party applications using the NVMS SDK, The SDK shall provide the following features to the third party software:

a) Connection
b) Video Streaming
c) Video overlays
d) PTZ Control
e) Audio-Streaming
f) Alarm Management
g) Event Management
h) Bookmark Management
i) Digital Output
j) Backup/export

11. The NVMS shall provide a process for upgrading versions:

    a) Upgrades shall be launched from the client interface.
    b) All connected servers and clients shall receive a distribution of the new version upgrade.

12. The NVMS shall run as a service configured to automatically start when the server or workstation is powered on.
13. The NVMS shall allow users to monitor and administer the system from:

    a) A single client application for monitoring live and recorded video and audio.
    b) A single window for administering all system connections.
    c) A single tab for monitoring overall system health and connected sites in parent- child relationships.
    d) Any client with access to a local or distributed network.

14. The NVMS shall provide multiple levels of system redundancy.
15. The NVMS shall provide the capability to rename all sites, servers, and video and audio sources.
16. The NVMS shall support the following video and audio recording programs:

    a) The ability to manually trigger recording.
    b) Provide a pre-event and post-event recording option.
    c) Provide a reference frame recording option in the absence of events.
    d) Create a recording schedule than can be defined individually for each video source.

17. The NVMS shall provide configurable classified object detection for each device with self- learning video analytics capabilities.

    a) Allow users to connect individual video sources to analytics appliance channels.
    b) Allow users to configure events based on classified object motion detection.
    c) Allow configured video analytics events to be used as alarm and rule triggers.
    d) Allow users to mark classified objects as a true or false detection.

18. The NVMS shall support the following video analytic event types when captured by supported cameras.

a) Objects in area.
b) Object loitering.
c) Object crossing defined line.
d) Object appears or enters area.
e) Object not present in area.
f) Object enter area.
g) Object leave area.
h) Object stops in area.
i) Anticipated direction of travel is violated.
j) Scene dramatically changes in an unexpected fashion.

19. The NVMS shall authenticate users before granting access to the system.
20. The NVMS shall provide access rights that can be tailored to each user or groups of users. Access rights include:

a) View live images.
b) View recorded images.
c) Manage saved images.
d) Manage maps
e) Manage web pages.
f) Manage virtual matrix monitors.
g) Initiate collaboration sessions.
h) Manage user sessions.
i) Listen to microphones.
j) Setup cameras.
k) Setup sites
l) Setup servers

21. The NVMS shall provide the ability to rank access rights based on a user's position within a configured.
22. The NVMS shall allow the creation of Site families.
23. The NVMS shall support multiple credentials to gain access to the system including, but not limited to:

a) The ability to import members of Active Directory groups as users in the NVMS.
b) Using Windows credentials to authenticate users.
c) Accept user credentials entered into the NVMS user database.

24. The NVMS shall provide the ability to schedule archive of recorded video with associated events to a local folder or mapped network drive.
25. The NVMS shall provide the ability to backup settings and configuration for each server including:

a) All site settings such as user/groups, maps and web pages.
b) All server settings including device connections.
c) Ability to encrypt the backup to maintain security of information.

26. The NVMS shall be able to restore backed-up settings and configurations to a new or replacement server in a Site.

27. The NVMS shall provide the ability to enable and configure PTZ control on the RS-485 interface of a video source.
28. The NVMS shall provide the ability to change the following image quality and image rate parameters for each individual video source.
29. The NVMS shall provide the ability to change supported video options at the client or video source.
30. The NVMS shall provide the ability to change the input, output, gain and volume for an audio source.
31. The NVMS shall support the use of uni-directional and bi-directional audio.
32. The NVMS shall provide the ability to link any audio source to any video source.
33. The NVMS shall provide the ability to manage and personalize user access.
34. The NVMS shall support the ability to bias the displayed video to a lower frame rate or lower image resolution if there is sufficient network bandwidth or processing power.
35. The NVMS shall provide the ability to control the client application using the following types of peripherals.

    a) A USB keyboard and/or mouse.
    b) A USB joystick.
    c) A PTZ controller keyboard.

36. The NVMS shall support the ability to share the application window display in a joint session with other users for collaborative investigations.
37. The NVMS shall provide a system tree of video sources, maps, saved views and web pages in the video monitoring tab.
38. The NVMS shall support an unlimited number of monitors used for monitoring video and audio streams connected to a single workstation.
39. The NVMS shall provide a Virtual Matrix application module.
40. The NVMS shall provide the option to display overlays on top of video images.
41. The NVMS shall support alarm management operations through the video monitoring interface.
42. The NVMS shall support the ability to manually trigger digital output.
43. The NVMS shall support the ability to create a map that represents the physical location of cameras and other devices throughout the surveillance system.
44. The NVMS shall support playback of recorded audio and video.
45. The NVMS shall support the following methods for navigating recorded video:

    a) Timeline shall list all displayed video sources.
    b) Timeline shall highlight motion and events in the recorded video.
    c) The NVMS shall support a timeline than can display down to quarter second increments.
    d) The NVMS shall support a timeline that can synchronize video displayed on multiple tabs to the same point in time.

46. The NVMS shall support recorded video search.

    a) Time
    b) Date
    c) Video Source
    d) Alarm

e) Event type
f) Visual search based on pre-defined image area, or image thumbnail.
g) Pixel motion or user defined areas.
h) Classified object motion detection on supported video analytics sources.
i) Bookmarks.

47. The NVMS shall support the ability to export media and provide the following options:

a) Export recorded video in the following formats:

i. Native (AVE)
ii. JPEG
iii. PNG
iv. TIFF
v. AVI
vi. Print

b) Export recorded audio in the following formats:

i. WAV
ii. Native (AVE)
iii. AVI

48. The NVMS shall have the ability of retaining all stored video for 30 calendar days based on 7.5 fps, full camera resolution with no compression, with a motion diversity factor of 50%. Image size will vary based on the camera type.

2.7 VIDEO MANAGEMENT SYSTEM WORKSTATION

A. Manufacturers:

1. TBD

B. Workstation

1.	Viewing Streams:	Up to 72
2.	Viewing Rate:	Up to 10 MB/s
3.	Operating System:	Windows 10
4.	Processor:	Intel Xeon Processor E3-1220V3
5.	Memory:	8 GB RAM
6.	Network Interface:	2 Gigabit Ethernet RJ-45 port (1000Base-T)
7.	Video Outputs:	2 active (1 DisplayPort and 1 DVI)
8.	Optical Drive:	1 DVD-RW
9.	Power Input:	100 to 240 VAC, 50/60 Hz, auto-switching
10.	Power Supply:	Single non-redundant
11.	Power Consumption:	320 W
12.	Supplied Accessories:	USB Keyboard, USB mouse, power cord, 1 DisplayPort to DVI adapter, (1) DVI to VGA

2.10 NETWORK VIDEO RECORDER

.

A. Manufacturers

1. TBD

B. Recorder

1.	Network Connection:	10 Gbe – with multiple network connections
2.	Recording Data Rate:	Up to 1350 Mbps
3.	Number of Cameras:	Up to 300
4.	Recording Storage Capacity:	Up to 160 TB raw, 137 TB effective (RAID 6)
5.	Network Interface:	2 x 10 GbE SFP+ ports
6.	Memory:	16 GB DDR4
7.	Operating System:	Microsoft Windows Server 2012 R2
8.	Processor:	Intel Xeon Processor E5-2620 V3, 2.4 GHz, 15M Cache
9.	Form Factor:	2U rack mount chassis
10.	Power Input:	100 to 240 VAC, 50/60 Hz, auto-switching
11.	Power Supply:	750 W redundant, hot-swappable
12.	Power Consumption:	Average: 429 W (1463.8 BTU/h), Maximum 750 W (25591.1 B TU/h)

2.11 SECURITY NETWORK EDGE SWITCH

A. Manufacturers:

1. Cisco
2. HP
3. Dell

B. Network Switch

1. (48) Ethernet 10/100/1000 ports
1. Forwarding Bandwidth: 108 Gbps
2. Switching Bandwidth: 216 Gbps
3. Forwarding Rate: 130 Mpps
4. Flash Memory: 128 MB
5. DRAM: 512 MB
6. MAC addresses: Up to 16,000
7. IGMP groups/Multicast routes: Up to 1000
8. Configurable MTU: 9216 Bytes with jumbo frames
9. 1000BaseT ports: RJ-45 connectors
10. Input power: 100 – 240 VAC, 50-60 Hz
11. Indicators:

a) Port link integrity
b) Port disabled

c) Port Activity
d) Port speed
e) Port full duplex
f) System status
g) System RPS
h) System link status
i) System link duplex
j) System PoE
k) System link speed

12. Operating Temp: 23° – 113° deg F
13. Operating relative humidity: 10 – 85% non-condensing
14. MTBF: 233,370 hours
15. Measured Power consumption: 66 watts
16. Certifications: UL listed, FCC part 15 Class A
17. POE: IEEE 802.3at

2.12 SECURITY NETWORK CORE SWITCH

A. Manufacturers:

1. Cisco
2. HP
3. Dell

B. Network Core Switch

1. (24) Ethernet 10/100/1000 ports
2. Forwarding Rate: 65.5 Mpps
3. Switching Fabric: 160 Gbps
4. Flash Memory: 64 MB
5. DRAM: 256 MB
6. MAC addresses: Up to 16,000
7. IGMP groups/Multicast routes: Up to 1000
8. Configurable MTU: 9216 Bytes with jumbo frames
9. 1000BaseT ports: RJ-45 connectors
10. Input power: 100 – 240 VAC, 50-60 Hz
11. Indicators:

a. Port link integrity
b. Port disabled
c. Port Activity
d. Port speed
e. Port full duplex
f. System status
g. System RPS
h. System link status
i. System link duplex
j. System PoE
k. System link speed

12. Operating Temp: 23° – 113° deg F

13. Operating relative humidity: 10 – 85% non-condensing
14. MTBF: 233,370 hours
15. Measured Power consumption:
16. Certifications: UL listed, FCC part 15 Class A
17. POE: IEEE 802.3at

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.

B. Examine roughing-in for LAN, WAN, and IP network before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

B. Wiring Method: Install cables in raceways unless otherwise indicated.

1. Except raceways are not required in accessible indoor ceiling spaces and attics.
2. Except raceways are not required in hollow gypsum board partitions.
3. Conceal raceways and wiring except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

E. For LAN connection and fiber-optic and copper communication wiring, comply with Section 271323 "Communications Optical Fiber Backbone Cabling" and Section 271523 "Communications Horizontal Cabling."

F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. Install cameras and infrared illuminators level and plumb.

B. Install cameras with 84-inch minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.

C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.

D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.

E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.

F. Avoid ground loops by making ground connections only at the control station.

G. Identify system components, wiring, cabling, and terminals according to Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:

a. Prepare equipment list described in "Informational Submittals" Article.
b. Verify operation of auto-iris lenses.
c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate

nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.

d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
e. Set and name all preset positions; consult Owner's personnel.
f. Set sensitivity of motion detection.
g. Connect and verify responses to alarms.
h. Verify operation of control-station equipment.

3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

E. Video surveillance system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:

1. Check cable connections.
2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.

3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
5. Provide a written report of adjustments and recommendations.

3.6 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION
282300

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. The system and all associated components shall be in accordance with the current edition enforced of the following:

1. Indiana Building Code
2. NFPA 72, National Fire Alarm Code
3. NFPA 70, National Electrical Code
4. NFPA 101, Life Safety Code
5. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilation Systems.
6. Local Jurisdiction Adopted Codes and Standards
7. ADA Accessibility Guidelines.

1.2 REFERENCES

A. National Fire Protection Association:

1. NFPA 72 - National Fire Alarm Code.

1.3 SUMMARY

A. This section covers fire alarm systems, including initiating devices, notification devices, controls and supervisory devices.

B. Work covered by this section includes the furnishing of labor, equipment, and materials for installation of the fire alarm system as indicated on the drawings and specifications.

C. The Fire Alarm System shall consist of all necessary hardware, equipment, and software programming to perform the following functions:

1. Fire alarm and detection operations.
2. Control and monitoring of fire suppression systems, HVAC equipment shut-down, and other equipment as indicated in the Contract Drawings and specifications.

B. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Non-system smoke detectors.
6. Heat detectors.
7. Notification appliances.
8. Device guards.
9. Remote annunciator.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Network communications.
13. System printer.
14. System client workstation.

1.4 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
    d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    e. Locate detectors according to manufacturer's written recommendations.
    f. Show air-sampling detector pipe routing.

13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by Authorities Having Jurisdiction prior to submitting them to Engineer. Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Upon receipt of comments from the Authorities Having Jurisdiction, submit them for review. Resubmit if required to make clarifications or revisions to obtain approval.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level IV minimum.

c. Licensed or certified by Authorities Having Jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.7 Sample Warranty: For special warranty.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.

3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one (1) unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one (1) unit.
3. Smoke Detectors, Fire Detectors, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one (1) unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one (1) unit of each type.
5. Keys and Tools: One extra set for access to locked or tamper-proofed components.
6. Audible and Visual Notification Appliances: One (1) of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level IV technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.11 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to adjacent facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Construction Manager no fewer than five (5) working days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Construction Manager's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.12 SEQUENCING AND SCHEDULING

A. New equipment put into service for protection of facilities shall remain fully operational as other new equipment is tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is tested and accepted. Remove labels from new equipment when put into service.

B. Temporary Equipment Removal: After acceptance of new fire-alarm system(s), remove temporarily connected fire-alarm equipment and wiring no longer used for protection of facilities.

1.13 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, a campus wide networked system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

1. The networked system provided shall be capable of fully operating in standalone mode if disconnected from the network.
2. The networked system provided shall provide redundancy where necessary to ensure a reliable system should critical network connections or components fail in operation.
3. Sequences of operation/control shall be submitted for Engineer, Owner, and AHJ review for scenarios where critical network connections or components fail in operation.

    a. Provide detailed matrices for device monitoring, alarm, and/or control actions.
    b. Provide detailed sequence for alarming – i.e. alarming at floor, at floor above, at floor below for high rise areas; i.e. - alarming at other buildings/facilities.

4. Fire Alarm Control Panels and other head-end fire/detection equipment shall be provided with all necessary hardware for networking. FACP will be networked to other site building FACPs via a Class A Style 7 network with level 2 survivability. Provide hardware for all necessary communication protocols for the exchange of all status points and/or control commands between fire alarm panels and other building panels; i.e. BACNET protocol for communication with Building Management System panels for smoke evacuation.

B. Non-coded, UL-certified addressable system, with multiplexed signal transmission and voice/horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Pre-action system.
7. Fire-extinguishing system operation.
8. Fire standpipe system.
9. Dry system pressure flow switch.
10. Other networked fire alarm control panels in adjacent buildings as required

by AHJ; adjacent buildings may not be provided with a fire separation barrier.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Activate voice/horn audible alarm communication system.
6. Activate strobe visible alarm communication system.

    a. Strobes shall be synchronous throughout the facility.

7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Activate pre-action system.
10. Record events in the system memory.
11. Record events by the system printer.
12. Indicate device in alarm on graphic annunciator HMIs (Human Machine Interfaces).
13. Notify other networked fire alarm control panel(s).

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe or pre-action sprinkler system.
3. Alert and Action signals of air-sampling detector system.
4. Independent fire-detection and -suppression systems.
5. User disabling of zones or individual devices.
6. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, remote annunciators, and off-premises.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Transmit system status to building management system(s).
5. Display system status on graphic annunciator(s).

2.3 FIRE-ALARM CONTROL UNIT

A. Vendor TBD by the Owner for the new Fire Alarm and Detection System.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Basis of Design Manufacturer/Model:

B. Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm manufacturer under the appropriate category by Underwriters Laboratories, Inc (UL) and shall bear the UL label. The manufacturer shall assume responsibility for compatibility of the system components.

C. General Requirements for Fire-Alarm Control Panel (FACP) Unit(s):

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 "Control Units for Fire-Protective Signaling Systems".

a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
b. Include a real-time clock for time annotation of events on the event recorder and printer.
c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
d. The FACP shall be listed for connection to a central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
4. Addressable horns, strobes, and speakers.

D. The following FACP hardware shall be provided:

1. Power Limited base panel with beige cabinet and door, 120VAC input power.
2. Capability to support up to 1,000 I/O points including up to 248 addressable devices (single and multi-point).
3. 100 points of Network Annunciation at FACP Display when applied as a Network Node.
4. 2000 points of annunciation where one (1) point of annunciation equals:
    a. 1 LED driver output on a graphic driver or 1 switch input on a graphic switch input module.
    b. 1 LED on panel or 1 switch on panel.
5. 8 Amp Power Supply with 3.3 Amp, temperature compensated, dual-rate battery charger. Battery charger voltage and amperage values shall be accessible on the FACP LCD display.
6. 2 Amp Auxiliary Power output with electronic overload protection, automatic restoral, and programmable operation for four-wire detector reset operation.
7. Panel shall be capable of adding 8 conventional zone circuits to connect to existing system devices for ease in retrofit applications.
8. Two IDNAC Class B or A Addressable Notification Appliance Circuits (NAC; rated 3A@24VDC, resistive). Each IDNAC shall support up to 64 addressable notification devices on a Single Signaling Line Circuit (SLC). Each SLC shall allow “T- tapping and shall not require an end of line resistor.
9. Where required, Remote Power Supplies with integral intelligent Notification Appliance Circuit Class B for system expansion.
10. One Auxiliary Relay with Form C contact rated for 2A @32VDC, programmable as a trouble relay, either as normally energized or de-energized, or as an auxiliary control.
11. Remote Unit Interface: supervised Class A (Style 7) signaling line circuit (SLC) for control and monitoring of remotely located annunciators and I/O panels.
12. The FACP shall support up to (5) RS-232-C ports and one service port. All (5) RS-232 Ports shall be capable of two-way communications.
13. Four (4) form "C" Auxiliary Relay Circuits (Form C contacts rated 2A @ 24VDC, resistive), operation is programmable for trouble, alarm, supervisory of other fire response functions. Relays shall be capable of switching up to 1/2 A @ 120VAC, inductive.
14. Programmable DACT for per Point Reporting.

E. Cabinet: Lockable enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provide exactly matching modular unit enclosures.

F. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu. Panel shall include an 80-character LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.

1. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters].

2. The system shall have the capability to provide remote expanded content, multi-line, operator interface displays. The expanded content multi-line displays shall be Quarter- VGA (QVGA) or larger and be capable of supporting a minimum of 854 standard ASCII characters to minimize or eliminate the levels of navigation required for access to information when responding to critical emergencies and abnormal system conditions. The QVGA operator interface shall provide operator prompts and six context sensitive soft-keys for intuitive operation.

a. Expanded content, multi-line operator interfaces shall be capable of providing the following functions:

1) Dual language operation with Instant-Switch language selection during runtime.
2) Activity display choices for:

a) First 8 events.
b) First 5 Events and Most Recent Event (with first and most recent event time and date stamps).
c) First Event and Most Recent Event (with first and most recent event time and date stamps).
d) Scrollable List Display [displays a scrollable list of active points for the event category (alarm, priority 2, supervisory, or trouble) selected. The position in this list will be the last acknowledged point (not flashing) at the top followed by the next 7 unacknowledged points (flashing)].
e) General Event Status (alarm, priority 2, supervisory, or trouble in system).
f) Site Plan.

3) Equal or hierarchal priority assignment. In systems with two or more operator interfaces, each operator interface shall be programmable to allow multiple operator interfaces to have equal operation priority or to allow hierarchal priority control to be assigned to individual operator interfaces (locations).
4) Up to 50 custom point detail messages for providing additional point specific information in detailed point status screens.

5) Bitmap file import for operator interface display of site plan and background watermark images. [Site plan status icons shall indicate area status for highest priority active events.]

b. Expanded content, multi-line displays shall have the capability to provide Dual- Language operation.

1) Language selection shall be via a switch on the operator interface panel. Operator interface panels shall support instant-language-switchover during runtime to allow the operator to toggle between languages each time the language selection switch is operated, without requiring complicated multi- step processes.
2) Both one-byte and two-byte characters shall be supported.

G. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 "Control Units for Fire-Protective Signaling Systems".

1. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.

2. Include a real-time clock for time annotation of events on the event recorder and printer.

3. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.

4. The FACP shall be listed for connection to a central-station signaling system service.

5. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

H. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.

I. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

J. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

a. Software: The fire alarm system shall allow for loading and editing Instructions

and operation sequences as necessary.

1. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation. All software operations shall be stored in a non-volatile programmable memory within the control unit. Loss of primary and secondary power shall not erase the instructions stored in memory.

2. Panels shall be capable of full system operation during new site specific configuration download, master exec downloads, and slave exec downloads. Remote panel site-specific software and executive firmware downloads shall be capable of being performed over proprietary fire alarm network communications and via TCP/IP Ethernet network communications. Ethernet access to any fire alarm panel shall be capable of providing access only to authenticated users through a cryptographically authenticated and secure SSL tunnel.

3. Panels shall automatically store all program changes to the panel's non-volatile memory each time a new program is downloaded. Panels shall be capable of storing the active site-specific configuration program and no less than 9 previous revisions in reserve. A compare utility program shall also be available to authorized users to compare any two of the saved programs. The compare utility shall provide a deviation report highlighting the changes between the two compared programs. Channels shall provide electronic file storage with a means to retrieve a record copy of the site-specific software and up to 9 previous revisions.

4. Sufficient file storage shall be provided for other related system documentation such as record drawings, record of completion, owner's manuals, testing and maintenance records, etc. The media used to store the record copy of site-specific software and other related system documentation shall be electrically supervised. If the media is removed a trouble shall be reported on the fire alarm control panel.

5. History Logs: The system shall provide a means to recall alarms and troubles in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided. Up to 2,000 events shall be capable of being stored in the history log.

6. Recording of Events: Record all alarm, priority two, supervisory, and trouble events by means of system printer. The printout shall include the type of signal (alarm, priority two, supervisory, or trouble) the device identification, date and time of the occurrence. The printout differentiates alarm signals from all other printed indications.

K. Remote Access:

1. Fire Alarm Control Panel (FACP) shall have the capability to provide a remote service access feature using Ethernet and TCP/IP communications protocol compatible with IEEE Standard 802.3. The Remote Access feature shall provide automatic notification of system faults and remote diagnostics of system status for responding technicians prior to arrival on site.

2. A standard RJ-45 Ethernet connection shall connect to the owners Ethernet network. Provisions for that connection must be provided at each fire alarm control panel as part of the contract.

3. The Ethernet access feature shall be agency listed for specific interfaces and for the purpose described in this section. The use of non-listed external third party interfaces is not acceptable.

4. The internet remote access service function shall provide automated real time off-site reporting of discrete system events to a remote service support center with details of internal FACP fault conditions allowing a pre-site visit analysis of repair requirements.

5. The remote service network shall work on the customers Ethernet infrastructure and be Fire-Wall friendly for two-way communications for off-site reporting. The feature shall be compatible with existing proxy servers and firewalls shall not require any special changes or modifications. **Systems must meet owner's ITRA requirements to be on network.**

6. The remote service system shall be able to connect to the remote service center without the need for a VPN account or similar tunnel.

7. The remote service system shall be a non Windows based application to protect against conventional virus attacks.

8. The remote service system shall support a secure connection with strong encryption,128 bit or better, and an optional secondary encryption method if required.

9. The remote service system shall be compatible with virtual LANS (VLAN).

10. The remote service system shall work on an outbound communication premise (panel calls home) in order to eliminate the possibility of any inbound connection into the network (from trusted or non trusted sites).

11. The remote service system shall provide an audit trail of all events and service connections.

12. The Remote Service connection will provide access for panel software downloads and uploads for archiving job specific programs back at the enterprise server.

13. The supplier shall provide a service contract for the Remote Service program that provides the following requirements:

    a. 24/7 recording of FACP service activity.

    b. Off-site diagnostics by a technical specialist to provide repair and parts guidance to the service technician prior to a site visit.

L. Required Functions: The following are required system functions and operating features:

1. Priority of Signals: Alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have second, third, and fourth level priority respectively. Signals of a higher priority level shall take precedence over signals of a lower priority level, even though the lower priority condition occurred first. Annunciate all events regardless of priority or order received.

2. Non-interfering: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent addressable device activations.

3. Transmission to an approved Supervising Station: Automatically route alarm, supervisory, and trouble signals to an approved supervising station service provider, under another contract.

4. Annunciation: Operation of alarm, priority two and supervisory initiating devices shall be annunciated at the FACP and the remote annunciator, indicating the type of device, the operational state of the device (i.e. alarm, trouble or supervisory) and shall display the custom label associated with the device.

5. General Alarm: A system general alarm shall include: Indication of alarm condition at the FACP and remote annunciators.

    a) Identification of the device that is the source of the alarm at the FACP and remote annunciators.
    b) Operation of audible and visible notification devices throughout the building until silenced at FACP.
    c) Unlocking designated doors.
    d) Shutting down supply and return fans serving zone where alarm is initiated.
    e) Closing of dampers on system serving zone where alarm is initiated.
    f) Transmission of signal to the off-site 24 hour remote monitoring service.

6. Supervisory Operations: Upon activation of a supervisory device, such as low air pressure switch, and tamper switch, the system shall operate as follows.

    a) Activate the system supervisory service audible signal and illuminate the LED at the FACP and remote annunciator.
    b) Pressing the Supervisory Acknowledge Key will silence the Supervisory LED "on" indicating off-normal condition.
    c) Record the event in the FACP history log.

d) Transmission of a supervisory signal to the 24 hour remote monitoring service.

7. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible alarm signals shall cease operation.

8. System Reset:

a) The "System Reset" button shall be used to extinguish the visual signals and return the system to its normal state. Display messages shall provide operator assurance of the sequential steps (IN PROGRESS", "RESET COMPLETED") as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-alarming the system. The display message shall indicate "ALARM PRESENT", SYSTEM RESET ABORTED".

b) Should an alarm condition continue, the system will remain in an alarmed state.

9. Drill: A manual evacuation (drill) switch shall be provided to operate the notification appliance without causing other control circuits to be activated.

10. WALKTEST: The system shall have the capacity of 8 programmable, password protected, one person testing groups, such that only a portion of the system need be disabled during testing. The actuation of the "enable one person test" program at the FACP shall activate the "One Person Testing" mode of the system as follows:

a. The city circuit connection shall be bypassed for the testing group.

b. Control relay functions associated to one of the 8 testing groups shall be bypassed.

c. The FACP shall indicate a trouble condition.

d. The alarm activation of any initiating device in the testing group shall cause the audible notification appliances to sound a voice announcement to identify the device.

e. The unit shall automatically reset itself after signaling is complete.

f. Any momentary opening of an initiating or notification appliance circuit wiring shall cause the audible signals to voice announce the trouble condition.

11. Install Mode: The system shall provide the capability to group all non-commissioned points and devices into a single "Install Mode" trouble condition allowing an operator to more clearly identify event activations from commissioned points and devices and in occupied areas.

a. It shall be possible to individually remove points from Install Mode as

required for phased system commissioning.

b. It shall be possible to retrieve an Install Mode report listing that includes a list of all points assigned to the Install Mode. Panels not having an install mode shall be reprogrammed to remove any non-commissioned points and devices.

12. Service Gateway: A Service Gateway software application shall be provided that allows an authorized service person to remotely query panel status during testing, commissioning, and service, without the need to return to the panel using standard email or instant messaging tools. For systems without a service gateway application the service provider shall provide a minimum of two technicians for any system testing or commissioning.

M. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class B.
2. Pathway Survivability: Level 1.
3. Install no more than 256 addressable devices on each signaling-line circuit.
4. Serial Interfaces:

a. One dedicated RS 485 port for central-station operation using point ID DACT.
b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
c. One USB port for PC configuration.
d. One RS 232 port for voice evacuation interface.

N. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events in system memory.
4. Record events by the system printer.
5. Sound general alarm if the alarm is verified.
6. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

O. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

P. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity- adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

Q. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

R. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

S. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals, and supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power- supply module rating.

T. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Vented, wet-cell pocket, plate nickel cadmium.

U. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 PRE-ACTION SYSTEM

A. Initiate Pre-signal Alarm: This function shall cause an audible and visual alarm and indication to be provided at the FACP. Activation of an initiation device connected as part of a pre-action system shall be annunciated at the FACP only, without activation of the general evacuation alarm.

2.5 MANUAL FIRE-ALARM BOXES

A. Basis of design: TBD

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box.

If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery- powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Multiple levels of detection sensitivity for each sensor.
    b. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors:

1. Basis of design: TBD

2. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
3. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors:

1. Basis of design: TBD

2. Photoelectric type complying with UL 268A.
3. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
4. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

5. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
6. Each sensor shall have multiple levels of detection sensitivity.
7. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

D. Relay Fan Shutdown: Each duct detector shall have a relay for fan shutdown.

1. Basis of Design: TBD

2. Fully programmable relay rated to interrupt fan motor-control circuit. Relay shall be located within 3 feet of the controlled device.

E. Remote Test Station: Each duct detector shall have a remote test station for fan shutdown.

1. Basis of Design: TBD or Approved Equal

2. Each duct detector shall have a Remote Test Station with alarm LED and Test Switch.

2.7 HEAT DETECTORS

A. Basis of design: TBD

B. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Basis of Design: TBD.

2. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

3. Mounting: Wall mounted unless otherwise indicated.
4. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
5. Flashing shall be in a temporal pattern, synchronized with other units.
6. Strobe Leads: Factory connected to screw terminals.
7. Mounting Faceplate: Factory finished, red.

2.9 NOTIFICATION APPLIANCE CIRCUIT (NAC) POWER EXTENDER

A. Basis of Design: TBD

B. The IDNAC NAC Power Extender panel shall be a stand-alone panel capable of powering up to 64 notification appliance circuits on a single SLC. Notification appliance circuits shall be Class B rated at 3 amps each. The 4010ES FACP shall provide capability to be expanded with up to 6 addressable IDNAC repeater panels.

C. The internal power supply & battery charger shall be capable of charging up 12.7 Ah batteries internally mounted or 18Ah batteries mounted in an external cabinet.

D. The NAC extender panel may be mounted close to the host control panel or can be

remotely located. The IDNET Addressable NAC Extender Panel when connected to an addressable panel shall connect to the host panel via an IDNet communications channel. Via the IDNET channel each output NAC can be individually controlled for general alarm or selective area notification.

E. When connected to a conventional (non-addressable panel) one or two standard notification appliance circuits from the main control panel may be used to activate all the circuits on the NAC power extender panel.

F. Alarms from the host fire alarm control panel shall signal the NAC power extender panel to activate. The panel shall monitor itself and each of its NACs for trouble conditions and shall report trouble conditions to the host panel.

G. Addressable Relay Modules:

1. Provide address-setting means on the module. Store an internal identifying code for control panel use to identify the module type.
2. Allow the control panel to switch the relay contacts on command.
3. Have a minimum of two normally open and two normally closed contacts available for field wiring.
4. Listed for controlling HVAC fan motor controllers.

2.10 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Surface mount cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

C. Provide a remote LCD Annunciator, where required, with the same "look and feel" as the FACP operator interface. The Remote LCD Annunciator shall use the same Primary Acknowledge, Silence, and Reset Keys; Status LEDs and LCD Display as the FACP.

D. Annunciator shall have super-twist LCD display with two lines of 40 characters each. Annunciator shall be provided with three (3) programmable control switches and associated LEDs.

E. Under normal conditions the LCD shall display a "SYSTEM IS NORMAL" message and the current time and date.

F. Should an abnormal condition be detected the appropriate LED (Alarm, Priority 2, Supervisory or Trouble) shall flash. The unit audible signal shall pulse for alarm and priority two conditions and sound steady for trouble and supervisory conditions.

1. 40-character custom location label.
2. Type of device (e.g., smoke, pull station, waterflow).
3. Point status (e.g., alarm, trouble).

G. Operator keys shall be key switch enabled to prevent unauthorized use. The key shall only be removable in the disabled position. Acknowledge, Silence and Reset operation shall be the same as the FACP.

2.11 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and/or to circuit-breaker shunt trip for power shutdown.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

E. Addressable Circuit Interface Modules: Arrange to monitor one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of water-flow, valve tamper, non-addressable devices, and for control of evacuation indicating appliances and AHU systems.

F. Addressable Circuit Interface Modules will be capable of mounting in a standard electric outlet box. Modules will include cover plates to allow surface or flush mounting. Modules will receive their operating power from the signaling line or a separate two wire pair running from an appropriate power supply as required.

G. There shall be three types of modules:

1. Type 1: Line Powered Monitor Circuit Interface Module.
   a. Basis of Design: TBD
   b. This module has both its power and its communications supplied by the two wire multiplexing signaling line circuit. It provides location specific addressability to an initiating device by monitoring the normally open dry contacts. This module is required for monitoring of water-flow and tamper switches.

2. Type 2: Monitor Circuit Interface Module.
   a. Basis of Design: TBD
   b. For conventional 2-wire smoke detector and/or device monitoring with class A or class B wiring supervision. The supervision of the zone wiring will be Class B. This module will communicate status (normal, alarm, trouble) to the FACP.

3. Type 3: Control Circuit Interface Module.
   a. Basis of Design: TBD
   b. Module for signals, speakers, and other device control with Style D and Style Z wiring supervision. For Non-Supervised Control: This type of module will provide double pole double throw relay switching for 2A @ 24VDC resistive, non-power limited. It shall contain easily replaceable 2 amp fuses, one on each common leg of the relay. The system shall be capable of energizing 100% of the relays connected to the signaling line circuit.
   c. The Circuit Interface Module shall be supervised and uniquely indentified by the control unit. Module identification shall be transmitted to the control unit for processing according to the programmed instructions. Modules shall have an on- board LED to provide an indication that the module is powered and communicating with the FACP. The LED's shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire- alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

   1. Verification that both telephone lines are available.
   2. Programming device.
   3. LED display.
   4. Manual test report function and manual transmission clear indication.
   5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.
9. Area of refuge trouble/loss of power.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.13 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

C. Provide integration gateway using protocol as necessary for connection to building automation system.

2.14 REMOTE ACCESS BY PERSONAL DIGITAL ASSISTANT (PDA) DEVICE

A. Maintenance personnel shall be provided access-limited with the ability to receive troubles and status on their personal digital assistant devices (i.e. mobile phone). Provide all necessary communications hardware and software (i.e. mobile dial-out, servers, network equipment, VPN, Wifi, etc.) to accommodate remote access.

1. Access shall be provided to the local fire department. Coordinate with Indianapolis Fire Department.

2.15 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.16 CLIENT WORKSTATION

A. Dell desktop computer with one (1) monitors and other accessories (mouse, keyboard, etc.).

B. Pre-loaded with HMI (Human Machine Interface) software for display of all networked

devices.

C. Pre-loaded with Microsoft Office and Microsoft Operating System

2.17 Printer shall be listed and labeled as an integral part of fire-alarm system.

2.18 CUP building layout shall be added to the site workstation that is being provided in the AAHC bid package.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of Authorities Having Jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Expand, modify, and supplement existing control/monitoring equipment as necessary to extend existing control/monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system. Integrate equipment with the networked fire alarm control panel(s) and supervising station(s).

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above

the finished floor.

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated; use 48” AFF unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

I. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Cabling pathways shall be installed in EMT.

B. Exposed EMT shall be factory pre-painted red enamel color. Junction boxes, pull boxes, and box covers shall be factory or field painted red enamel color.

3.4 POWER REQUIREMENTS

A. Head-end equipment panels shall be provided with 120VAC power via a dedicated 20 Ampere branch circuit. Branch circuit shall obtained from legally required panelboard(s) connected to a emergency power source.

B. Provide a red locking device on the circuit breaker(s) feeding the Control Unit to prevent "un- intended shutting off" of power to the panelboard(s).

C. The system shall be provided with sufficient battery capacity to operate the entire system, upon loss of normal 120VAC power in a normal supervisory mode, for a period of 24 hours with 5 minutes of alarm operation at the end of this period. The system shall automatically transfer to battery standby upon power failure. All battery charging and recharging operations shall be automatic.

D. All circuits requiring system-operating power shall be 24VDC and shall be individually fused at the control panel.

E. The incoming power to the system shall be supervised so that any power failure will be indicated at the control panel. A green "Power On" LED shall be displayed continuously while incoming power is present.

F. The system batteries shall be supervised so that a low battery condition or disconnection of the battery shall be indicated at the control panel.

G. The system shall support 100% of addressable devices in alarm or operated at the same time, under both primary (AC) and secondary (battery) power conditions.

H. Loss of primary power shall sound a trouble signal at the networked FACP. The networked FACP shall indicate when the system is operating on an alternate power supply.

3.5 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm

system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Electronically locked doors and access gates.
3. Supervisory connections at valve supervisory switches.
4. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
5. Data communication circuits for connection to Building Management System.
6. Supervisory connections for emergency generator control panels power failure status.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed emergency operating instructions in a location visible from each fire-alarm control panel unit.

3.7 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.8 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Authorities Having Jurisdiction.

1. Demonstration shall include integration into all necessary building systems. Engineer, Owner, Building Management System Vendors, Elevator Vendors, and Other Equipment Vendors shall be present at the demonstration for witnessing a complete and integrated system.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Pre-testing: Determine, through pre-testing, the conformance of the system to

the requirements of the Drawings and Specifications. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new and re-test until satisfactory performance and conditions are achieved.

E. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.

F. Minimum System Tests: Test the system in accordance to the procedures outlined in NFPA 72.

G. Perform the following tests and inspections with the assistance of a factory-authorized Service Representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

H. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

I. Fire-alarm system will be considered defective if it does not pass tests and inspections.

J. Prepare test and inspection reports.

K. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

L. Annual Test and Inspection: One year after date of Substantial Completion, test fire-

alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.9 LABELING OF DEVICES

A. Provide labeling on all alarm initiating devices to identify loop and device number. Labels hall be such that they are easily read and architecturally pleasing.

3.10 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Clean unit internally using methods and materials recommended by manufacturer.

B. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls and sensitivities to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

3.11 MAINTENANCE SERVICE CONTRACT

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization; using factory authorized, NICET certified technicians.

B. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Basic Services: Systematic routine maintenance visits on a quarterly basis at times scheduled with the Owner. In addition, respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies.

D. Additional Services: Perform services within the above 12-month period not classified as routine maintenance or as warranty work when authorized in writing. Compensation for additional services must be agreed upon in writing prior to performing services

E. Renewal of Maintenance Service Contract: Contractor shall provide monthly unit costs for monthly Maintenance Service Contract which provides contract maintenance and repair services for 60 months beyond the initial 12-month service contract. Owner will be under no obligation to accept this monthly maintenance service contract.

3.12 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to demonstrate fully operational and integrated system to the Authorities Having Jurisdiction. Contractor shall coordinate all persons required for this demonstration including interfaces to other systems (i.e. elevator, access control, building management system, fire pump, emergency generators, etc.). Demonstrate full operation sequence of alarming, notification, detection, and control of external equipment.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

1. Provide the services of a Factory-Authorized and NICET IV Certified service representative to demonstrate the system and train the Owner's maintenance personnel as specified below.

C. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventative maintenance of the system. Provide a minimum of eight (8) hours' training.

D. Schedule training with the Owner at least seven days in advance.

E. Examine areas and conditions under which the telephone and data systems are to be installed. Notify the Owner and Owner’s Construction Representative in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until satisfactory conditions have been corrected.

END OF SECTION 283111