PROJECT MANUAL

Construction Specifications

Volume # 03

Linton-Stockton Jr. Sr. High School Additions & Renovations

The SKILLMAN Corporation

AN EMPLOYEE-OWNED COMPANY

Wold VPS

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Two-piece ball valves with indicators.
2. Iron butterfly valves with indicators.
3. Check valves.
4. NRS gate valves.
5. Trim and drain valves.

1.2 DEFINITIONS

A. NRS: Nonrising stem.

B. OS&Y: Outside screw and yoke.

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. Ball Valves, System Control: HLUG - Level 3.
      b. Butterfly Valves: HLXS - Level 3.
      c. Check Valves: HMER - Level 3.
      d. 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. 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 .

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. 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: 175 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.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Globe Fire Sprinkler Corporation.
2. Milwaukee Valve Company.

2.4 IRON BUTTERFLY VALVES WITH INDICATORS

A. Description:
1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 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, nickel plated.
7. Actuator: Worm gear.
8. Supervisory Switch: Internal or external.
9. Body Design: Grooved-end connections.

2.5 CHECK VALVES

A. Description:
1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig .
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel.
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.

2.6 NRS GATE VALVES

A. Description:
1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig .
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron 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 or Threaded.

2.7 TRIM AND DRAIN VALVES

A. Ball Valves:
1.
2. Description:
   a. Pressure Rating: 175 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. Description:
   a. Pressure Rating: 175 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.

C. Globe Valves:
1. Description:
   a. Pressure Rating: 175 psig.
   b. Body Material: Bronze with integral seat and screw-in bonnet.
   c. Ends: Threaded.
   d. Stem: Bronze.
   e. Disc Holder and Nut: Bronze.
   f. Disc Seat: Nitrile.
   g. Packing: Asbestos free.
   h. 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 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-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 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.

D. Install valves in horizontal piping with stem at or above the pipe center.

E. Install valves in position to allow full stem movement.

F. 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

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Restraints - rigid type.
5. Restraints - cable type.
6. Restraint accessories.
7. Post-installed concrete anchors.

B. Related Requirements:

1. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

C. Delegated Design Submittal:

1. For each seismic-restraint device, including seismic-restrained mounting,pipe-riser resilient support,snubber,seismic restraint, seismic-restraint accessory,concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:

a. Seismic Selection: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.

c. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
e. Qualified Professional Engineer: All designated-design submittals for seismic calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.
f. equipment mounted outdoors.

2. Product Listing, Preapproval, and Evaluation Documentation: an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
3. All delegated design submittals for seismicrestraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.

D. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Welding certificates.

C. Field quality-control reports.

D. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in **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 fire-suppression system 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 (AHRI 1271), including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction.
2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-16.
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
4. The following fire-suppression systems and components are Designated Seismic Systems and require written special certification of seismic qualification by manufacturer:

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic 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: an agency acceptable to authorities having jurisdiction.

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 control system.

1. Seismic Performance: Equipment must be designed and secured to withstand the effects of earthquake motions determined in accordance with NFPA 13 and ASCE/SEI 7-16.

B. 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 NFPA 13 and ASCE/SEI 7-16 . 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. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
c. Building Risk Category: II.
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: Per ASCE/SEI 7-16 Section 11.4.5. 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 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" is 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}: 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) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculated by Delegated Design Contractor in accordance with ASCE/SEI 7-16, Paragraph 13.3.2.
2) Δ_{aA} = Allowable Story Drift for Structure A: See Drawing 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 fps^2 (9.81 m/s^2)**.
3) K_p = Combined Stiffness of Component, Supports, and Attachments: Determined by delegated design seismic engineer. .

4) S_{DS} = Spectral Acceleration: <**Insert value**>. Value applies to all components on Project.
5) I_p = Component Importance Factor: See Drawing Schedule for each component.
6) W_p = Component Operating Weight: For each component. Obtain by Delegated Design Contractor from equipment submittal.
7) δ_{xA} = Deflection at Building Level x of Structure A: See Drawing Schedule for each component.

C. Consequential Damage: Provide additional seismic and wind-load restraints for suspended fire-suppression system components or anchorage of floor-, roof-, or wall-mounted fire-suppression system 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 fire-suppression system component will not cause the failure of any other essential architectural, mechanical, or electrical 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 by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

E. 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/SEI 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:

a. Amber/Booth Co.

b. Cooper B-Line, Inc.

c. Hilti North America.

d. MIRO Indusrtries.

e. Seismic Control Products, LLC.

f. Simpson Strong Tie.
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. Neoprene rubber, silicone rubber, or other elastomeric material.
5. Surface Pattern: Smooth, ribbed, or waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.

7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material:Resilient .

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:

    a. Amber/Booth Co.

    b. Cooper B-Line, Inc.

    c. Hilti North America.

    d. MIRO Industries.

    e. Seismic Control Products, LLC.

    f. Simpson Strong Tie.
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- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:
    a. Amber/Booth Co.
    b. Cooper B-Line, Inc.
    c. Hilti North America.
    d. MIRO Indusrtries.
    e. Seismic Control Products, LLC.
    f. Simpson Strong Tie.
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 RESTRAINTS - RIGID TYPE

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:
    a. Amber/Booth Co.
    b. Cooper B-Line, Inc.
    c. Hilti North America.

d. MIRO Indusrtries.
e. Seismic Control Products, LLC.
f. Simpson Strong Tie.

B. 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.

2.6 RESTRAINTS - CABLE TYPE

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:
   a. Amber/Booth Co.
   b. Cooper B-Line, Inc.
   c. Hilti North America.
   d. MIRO Indusrtries.
   e. Seismic Control Products, LLC.
   f. Simpson Strong Tie.

B. Seismic-Restraint **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 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.

2.7 RESTRAINT ACCESSORIES

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:
   a. Amber/Booth Co.
   b. Cooper B-Line, Inc.
   c. Hilti North America.
   d. MIRO Indusrtries.
   e. Seismic Control Products, LLC.
   f. Simpson Strong Tie.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid restraints and restraint cables.

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.

2.8 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
1. Available manufacturers offering products that may be incorporated into the work include, but not limited to the following:
a. Amber Booth Co.
b. Cooper B-Line
c. Hilti North America.
d. MIRO Industries Inc.
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. Provide post-installed concrete anchors that have been prequalified for use in seismic applications. Post-installed concrete anchors must comply with all requirements of 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.

C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp (7.46 kW) that is not vibration isolated.

1. Undercut expansion anchors are permitted.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by 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 calculated static[, wind load,] and seismic loads within specified loading limits.

3.2 INSTALLATION OF VIBRATION CONTROL[, WIND-LOAD-RESTRAINT,] AND SEISMIC-RESTRAINT DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Fire-Suppression Vibration Isolation, Seismic, where indicated on Drawings, or where the Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraint devices for systems and equipment where indicated in Equipment Schedules or Vibration Isolation, Seismic, and Wind-Load-Restraint Schedules, where indicated on Drawings, where the 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 and seismic restraints must not cause any stresses, misalignment, or change of position of equipment or piping.

E. Comply with installation requirements of NFPA 13 for installation of all seismic-restraint devices.

F. Comply with requirements in Section 077200 "Roof Accessories" for installation of equipment supports and roof penetrations.

G. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

H. Piping Restraints:

1. Comply with all requirements in NFPA 13.
2. Design piping sway bracing in accordance with NFPA 13.

    a. Maximum spacing of all sway bracing to be no greater than indicated in NFPA 13.
    b. Design loading of all sway bracing not to exceed values indicated in NFPA 13.

I. Install seismicrestraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

J. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

K. 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.

L. 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.

M. 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 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. Mechanical-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. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross structural seismic joints and other points where differential movement may occur, 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 211000 "Water-Based Fire-Suppression Systems" for piping flexible connections.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. 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 no fewer W 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.

C. Remove and replace malfunctioning units and retest as specified above.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 210548

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Sprinkler piping specialties.
3. Specialty valves.
4. Sprinklers.
5. Pressure gauges.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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, prepared by NICET Level III-certified technician, "Water-Based Systems Layout." NICET certified-technician submittals are to include the following information on each drawing title block: technician's name, NICET certification number, and, NICET certification specialty area and level.

1.3 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. Field Test Reports: 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."

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 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 NICET Level III-certified technician, "Water-Based Systems Layout."

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.

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. Educational: Light Hazard.
   b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   c. General Storage Areas: Ordinary Hazard, Group 1.
   d. Offices, including Data Processing: Light Hazard.
   e. Stages: Ordinary Hazard, Group 2.
   f. Theaters and Auditoriums, excluding Stages and Prosceniums: Light Hazard.
3. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm/sq. ft. over 1500 sq. ft. area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm/sq. ft. over 1500 sq. ft. area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm/sq. ft. over 1500 sq. ft. area.
4. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 225 sq. ft..
   b. Storage Areas: 130 sq. ft..
   c. Mechanical Equipment Rooms: 130 sq. ft..
   d. Electrical Equipment Rooms: 130 sq. ft..
   e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

D. Obtain documented approval of sprinkler system design from authorities having jurisdiction.

2.2 STEEL PIPE AND FITTINGS

A. Schedule 40, 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 pipe, 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 ASME B16.21, nonmetallic and asbestos free 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.

I. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anvil; an ASC Engineered Solution.
   b. Victaulic Company.
2. Pressure Rating: 175-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. Specialty Valves Pressure Rating: 175-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. 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.

2.4 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. 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: 300 psig.

B. Automatic Air Vent:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AGF Manufacturing, Inc.
   b. CLA-VAL.
   c. Engineered Corrosion Solutions.
   d. Metraflex Company (The).
   e. Reliable Automatic Sprinkler Co., Inc. (The).
   f. Val-Matic Valve & Manufacturing Corp.

2. Description: Automatic air vent that automatically vents trapped air without human intervention.
3. Standard: UL listed or FM Global approved for wet-pipe fire sprinkler systems.
4. Vents oxygen continuously from system.
5. Float valve to prevent water discharge.
6. Minimum Water Working Pressure Rating: 175 psig.

C. Automatic Air Vent Assembly:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. AGF Manufacturing, Inc.
   b. Engineered Corrosion Solutions.
   c. Potter Electric Signal Company, LLC.
   d. South-Tek Systems, LLC.
2. Description: Automaticair vent assembly that automatically vents trapped air without human intervention, including Y-strainer and ball valve in a prepiped assembly.
3. Standard: UL listed or FM Global approved for use in wet-pipe fire sprinkler system.
4. Vents oxygen continuously from system.
5. Float valve to prevent water discharge.
6. Minimum Water Working Pressure Rating: 175 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. Anvil; an ASC Engineered Solution.
   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: 175-psig minimum.
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: 175-psig minimum.
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. Potter Electric Signal Company, LLC.
d. Potter Roemer LLC; a Division of Morris Group International.

2. Standard: UL 199.
3. Pressure Rating: 175 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. 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: 175-psig minimum.
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: 250-psig minimum.
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; an ASC Engineered Solution.
b. Reliable Automatic Sprinkler Co., Inc. (The).
c. 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: 175-psig minimum.
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. Venus Fire Protection Ltd.
5. Victaulic Company.
6. Viking Group Inc.

B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

C. Pressure Rating for Residential Sprinklers: 175-psig maximum.

D. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

E. Automatic Sprinklers with Heat-Responsive Element:
1. Nonresidential Applications: UL 199.
2.
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. Sprinkler Finishes: Chrome plated .

G. Special Coatings: Wax.

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: Chrome-plated steel, one piece, flat.
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.

J. PRESSURE GAUGES Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK, Inc.
2. Ashcroft Inc.
3. WIKA Instrument Corporation.

K. Standard: UL 393.

L. Dial Size: 3-1/2- to 4-1/2-inch diameter.

M. Pressure Gauge Range: 0- to 250-psig minimum.

N. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's existing interior Fire protection water-distribution piping.

B. Install shutoff valve, check valve, pressure gauge, and drain at connection to water supply.

3.2 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 unions adjacent to each valve in pipes NPS 2 and smaller.

D. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

E. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

F. Install sprinkler piping with drains for complete system drainage.

G. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

H. 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.

I. Install alarm devices in piping systems.

J. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

K. 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.

L. Fill sprinkler system piping with water.

3.3 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. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 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. Air Vent:

1. Provide at least one air vent 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 or globe valve, and strainer upstream of automatic air vent.
3. Pipe from outlet of air vent to drain.

3.5 INSTALLATION OF SPRINKLERS

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.6 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.

3.7 FIELD QUALITY CONTROL

A. Perform the following 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 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.

3.8 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.

3.9 PIPING SCHEDULE

A. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2 (DN 50) and Smaller, is to Be the Following:

1. Standard-weight, Schedule 40 black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

B. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), is to Be of the Following:
1. 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.

C. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 5 (DN 125) and Larger, is to Be the Following:

1. 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.

3.10 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Semi-recessed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Pendent, dry sprinklers Sidewall, dry sprinklers Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Semi-recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
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 211313

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Sleeves without waterstop.
2. Sleeves with waterstop.
3. Sleeve-seal systems.
4. Grout.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pipe sleeve, sleeve seals and grout.

PART 2 - PRODUCTS

2.1 SLEEVES WITHOUT WATERSTOP

A. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.

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; a division of EnPRO Industries.
4. Metraflex Company (The).

B. Description: Manufactured PVC/HDPE, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

2.3 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; a division of EnPRO Industries.
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: Carbon steel.
   4. Connecting Bolts and Nuts: Carbon steel, with ASTM B633 coating of length required to secure pressure plates to sealing elements.

2.4 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 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, seal the space around outside of sleeves.

3.3 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.

3.4 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.
2. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.5 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.

END OF SECTION 220517

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Escutcheons.

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
6. ProFlo; a Ferguson Enterprises, Inc. brand

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

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. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
d. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
e. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 220518

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Bronze ball valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. RPTFE: Reinforced polytetrafluoroethylene.

C. WOG: Water, oil, gas.

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 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 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Standards:
1. Domestic water valves intended to convey or dispense water for human consumption must comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or must be certified to be in compliance with NSF 61 and NSF 372 (by an ANSI-accredited third-party certification body) that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
   a. ASME Compliance:
2. ASME B1.20.1 for threads for threaded end valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for cast copper solder-joint connections.
5. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
6. ASME B31.9 for building services piping valves.

B. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

E. Valve Actuator Type:
1. Hand Lever: For quarter-turn valves smaller than NPS 4.

F. Valves in Insulated Piping:
1. Provide 2-inch extended neck stems.
2. Extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.

2.3 BRONZE BALL VALVES

A. Bronze Ball Valves, Two Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:
1. Manufacturers:
   a. Apollo
   b. Mueller
   c. Nibco
   d. American Valve
   e. Red-White Valve.
2. Standard: MSS SP-110; MSS SP-145.
3. CWP Rating: 400 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Bronze or brass.
9. Ball: Chrome-plated brass.
10. 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. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.

B. Provide support to piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. For valves in horizontal piping, install valves with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. Valve Tags: Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

G. Adhere to manufacturer's written 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 exhibiting leakage.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, provide the same types of valves with higher CWP ratings.

B. Select valves with the following end connections:
For Copper Tubing, 2" and Smaller: Threaded ends except where solder-joint valve-end option.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2" and Smaller:
1. Bronze ball valves, two piece with full port, and bronze or brass trim. Provide with threaded or solder-joint ends.

END OF SECTION 220523.12

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron, single-flange (lug-type) butterfly valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

C. NBR: ABS, Buna-N, or nitrile 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, 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.

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 specialties intended to convey or dispense water for human consumption must comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or must be certified to be in compliance with NSF 61 and NSF 372 (by an 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 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 services valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-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. Valve Actuator Types:
1. Hand lever: For valves NPS 6 and smaller.

G. Valves in Insulated Piping: Provide 2-inch extended neck stems.

2.3 IRON, SINGLE-FLANGE (LUG-TYPE) BUTTERFLY VALVES

A. Iron, Single-Flange (Lug-Type) Butterfly Valves with Aluminum-Bronze Disc:

1. Manufacturers:
   a. Apollo
   b. Mueller
   c. Nibco
   d. American Valve
   e. Red-White Valve.
   f. Watts.

2. Standard: MSS SP-67, Type I.
3. CWP Rating: 200 psig .
4. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
5. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
6. Seat: EPDM.
7. Stem: One- or two-piece stainless steel.
8. Disc: Aluminum bronze.

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. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.

B. Provide support to piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. 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. If leakage cannot be repaired, replace valves.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange (Lug-Type) Butterfly Valves: 200 CWP, EPDM seat, and aluminum-bronze disc.

END OF SECTION 220523.13

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Bronze, swing 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 B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B16.18 for cast-copper solder joint.
4. ASME B16.22 for wrought copper solder joint.
5. 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 SWING CHECK VALVES

A. Bronze, Swing Check Valves Manufacturers:
   a. Apollo
   b. Mueller
   c. Red-White
   d. Watts
   e. Nibco
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.

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 press.

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.

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 valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded, soldered connections.
2. For Copper Tubing, NPS 2-1/2 to NPS 4Flange or threaded.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze, swing check valves with bronze disc, Class 125, with soldered or threaded end connections.

END OF SECTION 220523.14

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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions

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.

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 C552, Type II cellular glass with 100-psig or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psig or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-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 PIPE-POSITIONING SYSTEMS

A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

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 A36/A36M 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. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. 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.

H. 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.

I. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

J. 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.

K. 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. 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.

4. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 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.

3.4 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 copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal hanger-shield inserts for insulated piping and tubing.

I. 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. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NP 8.
3. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
6.

J. 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.

K. 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.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
5. C-Clamps (MSS Type 23): For structural shapes.
6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
10. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
11. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
12. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

M. 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.

N. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

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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. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraints - rigid type.
14. Restraints - cable type.
15. Restraint accessories.
16. Post-installed concrete anchors.

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.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

C. Delegated-Design Submittal:

1. For each seismic-restraint device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, and concrete anchor and insert, that is required by this Section or is indicated on Drawings, submit the following:

    a. Seismic restraint, and vibration isolator, and isolation base selection: Select vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.

    b. 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 by professional engineer that riser system was examined for excessive stress and that none exists.

    c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.

    d. Seismic Design Calculations: Submit all input data and loading calculations prepared in "Performance Requirements" Article in "Seismic Design Calculations" Paragraph.

    e. Qualified Professional Engineer: All designated-design submittals for seismic calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.
2. Seismic Restraint Detail Drawing:

    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 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 also with requirements in other Sections for equipment mounted outdoors.

3. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
4. All delegated-design submittals for seismic detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.3 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. Welding certificates.

C. Field quality-control reports:

D. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in 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 plumbing 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 (AHRI 1271), including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction ASCE/SEI 7-16.
2. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
3. The following plumbing systems and components are Designated Seismic Systems and require written special certification of seismic qualification by manufacturer:

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the 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 an agency acceptable to authorities having jurisdiction.

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 control system.

1. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7-16.

B. 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 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. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.

c. Building Risk Category[III.

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: Per ASCE/SEI 7-16 Section 11.4.5 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 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" shall 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 Dpl: 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) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculated by Delegated-Design Contractor in accordance with ASCE/SEI 7-16, Paragraph 13.3.2.
2) I_e = Structure Importance Factor: Per ASCE/SEI 7-10 Section 1.5.1. 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 fps^2 .
3) K_p = Combined Stiffness of the Component, Supports, and Attachments: Determined by delegated-design seismic engineer.
4) δ_{xA} = Deflection at Building Level x of Structure A: See Drawing Schedule for each component.

C. Consequential Damage: Provide additional seismic and wind-force restraints for suspended plumbing components or anchorage of floor, roof or wall mounted plumbing components as indicated in ASCE/SEI 7-16 so that failure of a non-essential or essential plumbing component will not cause the failure of any other essential architectural, mechanical or electrical building component.

D. 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.

E. 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/SEI 7-16 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads: .

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:

   a. Amber/Booth Co.

   b. Cooper B-Line, Inc.

   c. Hilti North America.

   d. MIRO Indusrtries.

   e. Seismic Control Products, LLC.

   f. Simpson Strong Tie.

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. Neoprene rubber, silicone rubber, or other elastomeric material.
5. Surface Pattern: Smooth, ribbed, or waffle 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, ribbed, or waffle 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, available manufacturers offering that may be incorporated into the work, include the following:

   a. Amber/Booth Co.

   b. Cooper B-Line, Inc.

   c. Hilti North America.

   d. MIRO Industries.

e. Seismic Control Products, LLC.

f. Simpson Strong Tie.

B. Mounting Plates:

1. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.

2. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:

a. Amber/Booth Co.

b. Cooper B-Line, Inc.

c. Hilti North America.

d. MIRO Indusrtries.

e. Seismic Control Products, LLC.

f. Simpson Strong Tie.

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 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators: .

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:

1. Amber/Booth Co.

2. Cooper B-Line, Inc.

3. Hilti North America.

4. MIRO Indusrtries.

5. Seismic Control Products, LLC.

6. Simpson Strong Tie.

7. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
8. Minimum Additional Travel: 50 percent of the required deflection at rated load.
9. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
10. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
11. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
12. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:

a. Amber/Booth Co.

b. Cooper B-Line, Inc.

c. Hilti North America.

d. MIRO Industries.

e. Seismic Control Products, LLC.

f. Simpson Strong Tie.

2. 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 shall limit floor load to 500 psig.

b. Top plate with threaded mounting holeselastomeric pad.

c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
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.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering that may be incorporated into the work, include the following:

a. Amber/Booth Co.

b. Cooper B-Line, Inc.

c. Hilti North America.

d. MIRO Indusrtries.

e. Seismic Control Products, LLC.

f. Simpson Strong Tie.

2. 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 shall limit floor load to 500 psig .
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

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.

2.8 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. Manufactures: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work 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.

a. Amber Booth Co.

b. Cooper B-Line

c. Hilti North America.

d. MIRO Industries Inc.

2.9 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. 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.

2.10 ELASTOMERIC HANGERS

Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: Available manufacturers offering products that may be incorporated into the work include, but not linited to the following:

a. Amber Booth Co.

b. Cooper B-Line

c. Hilti North America.

d. MIRO Industries Inc.

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. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.

2.11 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

B. Available manufacturers offering products that may be incorporated into the work include, but not limited to the following:

a. Amber Booth Co.

b. Cooper B-Line

c. Hilti North America.

d. MIRO Industries Inc.

2. 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.
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. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.12 SNUBBERS

A. Available manufacturers offering products that may be incorporated into the work include, but not limited to the following:

a. Amber Booth Co.

b. Cooper B-Line

c. Hilti North America.

d. MIRO Industries Inc.

B. 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 318-11 Appendix D for 2012 IBC Preset concrete inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.

2. Anchors in Masonry: Design in accordance with TMS 402.
3. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
4. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.13 RESTRAINTS - RIGID TYPE

A. Description: Shop- or field-fabricated bracing assembly made of ANSI/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.

2.14 RESTRAINTS - CABLE TYPE

A. Available manufacturers offering products that may be incorporated into the work include, but not limited to the following:

   a. Amber Booth Co.

   b. Cooper B-Line

   c. Hilti North America.

   d. MIRO Industries Inc.

B. Seismic Restraint 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. 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.

2.15 RESTRAINT ACCESSORIES

A. Available manufacturers offering products that may be incorporated into the work include, but not limited to the following:

   a. Amber Booth Co.

   b. Cooper B-Line

   c. Hilti North America.

   d. MIRO Industries Inc.

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.
3. Valve tags.

B. Related Requirements:

1.2 ACTION SUBMITTALS

A. Valve-numbering scheme.

B. Valve Schedules: For each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inche, 1/2 inch for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
6. Fasteners: Stainless steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. 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.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

B. Letter and Background Color: As indicated for specific application under Part 3.

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. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.3 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain or S-hook].

B. Letter and Background Color: As indicated for specific application under Part 3.

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. Include valve-tag schedule in operation and maintenance data.

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 INSTALLATION, GENERAL 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.

D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS

A. Permanently fasten labels on each item of plumbing equipment.

B. Sign and Label Colors.

1. White letters on an ANSI Z535.1 safety-green background.

C. Locate equipment labels where accessible and visible.

3.4 INSTALLATION OF PIPE LABELS

A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

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. Within 3 ft. of each valve and control device.
2. At access doors, manholes, and similar access points that permit view of concealed piping.
3. Within 3 ft. of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft**.** in areas of congested piping and equipment.

C. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

D. Flow-Direction Flow Arrows: Use arrows, in compliance with ASME A13.1, to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. Pipe-Label Color Schedule:

1. Domestic Cold-Water Piping: White letters on an ANSI Z535.1 safety-green background.
2. Domestic Hot-Water Piping: White letters on an ANSI Z535.1 safety-green background.
3. Domestic Hot-Water Return Piping White letters on an ANSI Z535.1 safety-green background.

4. Sanitary Waste Piping: White letters on a black background.
5. Storm Piping: White Letters on an ANSI Z535.1 safety-green background.
6. Natural Gas Piping: Black Letters on a Yellow background.

3.5 INSTALLATION OF VALVE TAGS

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 in the operating and maintenance manual.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:

1. Valve-Tag Size and Shape:

a. Domestic Cold Water: 1-1/2 inches, round.
b. Domestic Hot Water: 1-1/2 inches, round.
c. Domestic Hot-Water Return: 1-1/2 inches, round.
d. Natural Gas: 1-1/2 inches, round.

2. Valve-Tag Colors:

a. For each piping system, use the same lettering and background coloring system on valve tags as used in the piping system labels and background.

END OF SECTION 220553

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. TAB of domestic water system.

2. Pipe-leakage test verification.
3. Testing, adjusting, and balancing of existing plumbing systems and equipment.

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.

1.4 INFORMATIONAL SUBMITTALS

A. Certified TAB reports.

1.5 QUALITY ASSURANCE

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC.

B. 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 orTABB].

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE 111 Compliance: Requirements in ASHRAE 111 applicable to analogous domestic water system and plumbing equipment balancing.

E. ASHRAE 188 Compliance: Comply with balancing and report requirements, Section 8.3 "Balancing."

F. Code and Authorities Having Jurisdiction Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

PART 2 - Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 3 - PRODUCTS (Not Applicable)

PART 4 - EXECUTION

4.1 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, and balancing valves and fittings. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine approved submittals for plumbing systems and equipment.

D. Examine design data, including plumbing system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about plumbing system and equipment controls.

E. Examine system and equipment installations, and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

F. Examine test reports specified in individual system and equipment Sections.

G. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainers are installed and clean.

H. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

I. 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.

4.2 PREPARATION

A. Perform system-readiness checks of plumbing systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Domestic Water System:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed in accordance with applicable code and authority having jurisdiction.
b. Piping is complete and all points of outlet are installed.
c. Systems are flushed, filled, and air purged.
d. Suitable access to balancing devices and equipment is provided.

4.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Cut insulation, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. Where holes for probes are required in piping or equipment, install pressure and temperature test plugs to seal systems.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 220719 "Plumbing Piping Insulation."

B. Mark equipment and balancing devices, including valve position indicators and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

C. Take and report testing and balancing measurements in inch-pound (IP) units.

4.4 PROCEDURES FOR DOMESTIC WATER SYSTEMS

A. Prepare domestic water systems for testing and balancing as follows:
1. Check remotest point of outlet for adequate pressure.
2. Check flow-control valves for proper position.
3. Check that air has been purged from the system.

4.5 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record flows, temperatures, and pressures of each piece of equipment. Compare the values to design or nameplate information, where information is available.

4.6 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to plumbing systems and general construction to allow access for performance-measuring and -balancing devices.

END OF SECTION 220593

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. 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).

1.3 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.

1.4 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.

1.5 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.

1.6 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.

2.2 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. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

D. 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. Preformed Pipe Insulation: Type I, Grade A**,** with factory-applied ASJ.
2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 ADHESIVES

A. Glass-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

B. Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

C. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

2.4 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 58 to plus 176 deg F.
3. Color: White or gray.

C. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
1. Fire- and water-resistant, flexible, elastomeric sealant.
2. Service Temperature Range: Minus 40 to plus 250 deg F.
3. Color: White.

2.5 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.

2.6 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.

2.7 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
1. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies, off-set drain grids and trap and drain piping. Comply with Americans with Disabilities Act (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. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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. Keep insulation materials dry during storage, 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.

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. Testing agency labels and stamps.
2. Nameplates and data plates.
3. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

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 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 preformed fitting 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 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. 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.

E. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

F. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of cellular-glass insulation to valve body.
2. 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.

3.6 INSTALLATION OF GLASS-FIBER 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 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.

3.7 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. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.8 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation is the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

2. NPS 1-1/4 and Larger: Insulation is the following:
   a. 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 the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/2 and Larger: Insulation is the following:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Storm Piping and Drain Bodies:
1. NPS 3” and larger:
   a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

END OF SECTION220719

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Piping joining materials.
3. Transition fittings.
4. Dielectric fittings.

1.2 331415ACTION SUBMITTALS

A. Product Data:

1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.

1.3 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372. Include marking "NSF-pw" on piping.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type L (ASTM B88M, Type B)

B. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

D. Wrought Copper Unions: ASME B16.22.

E. Copper Tube, Pressure-Seal-Joint Fittings:

1. Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end.
2. Minimum 200-psig working-pressure rating at 250 deg F .

2.3 PIPING JOINING MATERIALS

A. Solder Filler Metals: ASTM B32, lead-free alloys.

B. Flux: ASTM B813, water flushable.

2.4 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.

C. Sleeve-Type Transition Coupling: AWWA C219.

2.5 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. Standard: ASSE 1079.
2. Pressure Rating: 125 psig minimum at 180 deg F .
3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Nipples:
1. Standard: IAPMO PS 66.
2. Electroplated steel nipple complying with ASTM F1545.
3. Pressure Rating and Temperature**:** 300 psig at 225 deg F.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
1. Drawn-temper copper tube, ASTM B88, Type L (ASTM B88M, Type B) wrought-copper, solder-joint fittings; and soldered joints.
2. Drawn-temper copper tube, ASTM B88, Type L (ASTM B88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.

C. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be the following:

1. Drawn-temper copper tube, ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and soldered joints.
2. Drawn-temper copper tube, ASTM B88, Type L (ASTM B88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.

3.2 312000INSTALLATION OF PIPING

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 valves according to 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."

D. Install domestic water piping level without pitch and plumb.

E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

F. 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.

G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

H. Install piping to permit valve servicing.

I. 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.

J. Install piping free of sags and bends.

K. Install fittings for changes in direction and branch connections.

L. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

M. 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. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."

E. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools and procedure recommended by pressure-seal-fitting manufacturer. Leave insertion marks on pipe after assembly.

F. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 INSTALLATION OF TRANSITION FITTINGS

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.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition unions.

3.5 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 unions.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Install hangers for copper 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.

C. Support horizontal piping within 12 inches of each fitting.

D. Support vertical runs of copper 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. 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. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
   2. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 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.

3.10 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.

3.11 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. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 221116

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Balancing valves.
2. Strainers for domestic water piping.
3. Hose bibbs.
4. Wall hydrants.
5. Drain valves.
6. Water-hammer arresters.

B. Related Requirements:

1. Section 220500 "Common Work Results for Plumbing."
2. 2211162232002243002245 00Section 224716 "Pressure Water Coolers" for water filters for water coolers.

1.2 2247232309233314 15ACTION 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.

1.3 INFORMATIONAL SUBMITTALS

A. Test and inspection reports.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 0160000160 00GENERAL 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. 221116Minimum Working Pressure for Domestic Water Piping Specialties: **125 psig** unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers
1. Standard: ASSE 1011.
2. Body: Bronze, nonremovable, with manual drain.
3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
4. Finish: **Chrome or nickel plated**.

2.4 BALANCING VALVES

A. Memory-Stop Balancing Valves :

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. Bell & Gossett.
b. Nexus.

2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
4. Size: NPS 2 (DN 50) or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass or stainless steel.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.5 HOSE BIBBS

A. Hose Bibbs:

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. WATTS; A Watts Water Technologies Company.
d. Woodford Manufacturing Company.
e. 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 (DN 15 or DN 20) threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig (860 kPa).
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** or **Operating key**.
14. Operation for Finished Rooms: **Operating key**.
15. Include operating key with each operating-key hose bibb.
16. Include **integral** wall flange with each chrome- or nickel-plated hose bibb.

2.6 WALL HYDRANTS

A. Nonfreeze Wall Hydrants :

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. WATTS; A Watts Water Technologies Company.
e. Woodford Manufacturing Company.
f. Zurn Industries, LLC.

2. Standard: ASME A112.21.3M for **concealed**-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
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 (DN 20 or DN 25).
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**.

2.7 DRAIN VALVES

Copy "Ball-Valve-Type, Hose-End Drain Valves" Paragraph below and re-edit for each type of drain valve required. If only one type is required, drawing designation may be omitted.

Insert drawing designation. Use these designations on Drawings to identify each product.

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 (2760-kPa) minimum CWP.
3. Size: NPS 3/4 (DN 20).
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.

2.8 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters :

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 Manufacturing Company, Inc.
   e. WATTS; A Watts Water Technologies Company.
   f. Zurn Industries, LLC.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: **Metal bellows**.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

A. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.

B. 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 260519260526260523IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
1. Balancing valves.

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."

3.4 ADJUSTING

A. Set field-adjustable flow set points of balancing valves.

3.5 FIELD QUALITY CONTROL

A. Testing Agency:**Engage** a qualified testing agency to perform tests and inspections.

See Section 014000 "Quality Requirements" for retesting and reinspection requirements and Section 017300 "Execution" for requirements for correcting the Work.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION221119

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Hubless, cast-iron soil pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe fittings.

B. Related Requirements:

1. Section 221313 "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.

1.2 ACTION SUBMITTALS

A. Product data.

1.3 INFORMATIONAL SUBMITTALS

A. 220548Field quality-control reports.

1.4 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. 221319Soil, Waste, and Vent Piping: 10 ft. head of water.

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 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Charlotte Pipe and Foundry Company.
2. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings:

1. Marked with CISPI collective trademark.
2. ASTM A888 or CISPI 301.

C. CISPI, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ANACO-Husky.
b. Charlotte Pipe and Foundry Company.
c. Mission Rubber Company, LLC; a division of MCP Industries.
d. Tyler Pipe; a subsidiary of McWane Inc.
e. MIFAB.

2. Standards: ASTM C1277 and CISPI 310.
3. Description: Stainless steel corrugated shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

D. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ANACO-Husky.
b. Charlotte Pipe and Foundry Company.
c. Mission Rubber Company, LLC; a division of MCP Industries.
d. Tyler Pipe; a subsidiary of McWane Inc.
e. MIFAB.

2. Standards: ASTM C1277 and ASTM C1540..
3. Description: Stainless steel shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.4 PVC PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Charlotte Pipe and Foundry Company.
2. National Pipe and Plastic, Inc.
3. North America Pipe Corporation.

B. Comply with NSF 14 for plastic piping components. Include "NSF-dwv" marking for plastic drain, waste, and vent piping and "NSF-sewer" marking for plastic sewer piping.

C. Solid-Wall PVC Pipe: ASTM D2665 drain, waste, and vent.

D. PVC Socket Fittings: ASTM D2665, made in accordance with ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

E. Adhesive Primer: ASTM F656.

F. Solvent Cement: ASTM D2564.

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) Fernco Inc.
        2) Mission Rubber Company, LLC; a division of MCP Industries.

    b. Standard: ASTM C1173.
    c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring 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.
    e. Sleeve Materials:

        1) For Cast-Iron Soil Pipes: ASTM C564, rubber.
        2) For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926 PVC.

4. For Dissimilar Pipes: ASTM D5926 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.

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. 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.

K. 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.

L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: Two percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Vent Piping: One percent down toward vertical fixture vent or toward vent stack.

M. 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."

N. Install underground PVC piping in accordance with ASTM D2321.

O. Plumbing Specialties:

1. 221319Install 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."

2. Install drains in sanitary waste gravity-flow piping.

   a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Q. 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."

R. 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."

S. 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. 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.

B. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2.
3. PVC Piping: Join in accordance with ASTM D2855 and ASTM D2665 appendixes.

C. 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.

3.5 VALVE INSTALLATION

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. 220548Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment"220548.

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.

B. Install hangers for cast-iron 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.

C. Support horizontal piping and tubing within 12 inches of each fitting**, valve,** and coupling.

D. Support vertical runs of cast-iron 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.

D. 221319Where installing piping adjacent to equipment, allow space for service and maintenance 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. Aboveground, soil and waste piping NPS 4 and smaller are to be the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.

B. Aboveground, soil and waste piping NPS 5 and larger are to be the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.

C. Aboveground, vent piping NPS 4 and smaller is to be any of the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

D. Aboveground, vent piping NPS 5 and larger is to be the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

E. Underground, soil, waste, and vent piping NPS 4 and smaller are to be any of the following:
1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

F. Underground, soil and waste piping NPS 5 and larger are to be the following:

1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 221316

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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.

1.3 DEFINITIONS

A. ABS: Acrylonitrile butadiene styrene.

B. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

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. Standard: ASME A112.36.2M.
2. Size: Same as connected drainage piping
3. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Raised-head, plastic plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:

1. Manufacturers:
a. Zurn.
b. J.R. Smith
c. Wade.
d. Sioux Chief.
e. Mifab.

2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing
5. Body or Ferrule: Cast iron.
6. Outlet Connection: Spigot.
7. Closure: Plastic plug.
8. Adjustable Housing Material: Cast iron withset screws..
9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
10. Frame and Cover Shape: Round.
11. Top-Loading Classification: Heavy Duty.
12. Riser: ASTM A74, Service Class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts :

1. Manufacturers:
a. Zurn.
b. J.R. Smith
c. Sioux Chief.
d. Mifab.
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. Plastic.
b. 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, 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.

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. 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. Install deep-seal traps on floor drains and other waste outlets, if indicated.

E. Install wood-blocking reinforcement for wall-mounting-type specialties.

F. 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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Floor drains.

2. Shower drains.

1.2 DEFINITIONS

A. ABS: Acrylonitrile-butadiene styrene.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene.

D. PE: Polyethylene.

E. PP: Polypropylene.

F. PVC: Polyvinyl chloride.

1.3 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:

a. Zurn.
b. J.R. Smith.
c. Wade.
d. Sioux Chief.
e. Mifab.

2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Outlet: Bottom.
7. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant enamel.
8. Top or Strainer Material: Bronze.
9. Top of Body and Strainer Finish: Polished Nickel-bronze.
10. Top Shape: Round.
11. Trap Pattern: Deep-seal P-trap.

B. Cast-Iron Shower Drains:

1. Manufacturers:
   a. Zurn.
   b. J.R. Smith.
   c. Wade.
   d. Sioux Chief.
   e. Mifab.
2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Outlet: Bottom.
7. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant enamel.
8. Top or Strainer Material: Bronze.
9. Top of Body and Strainer Finish: Polished Nickel-bronze.
10. Top Shape: Round.
11. Trap Pattern: Deep-seal P-trap.

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.

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. CONNECTIONS

C. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

D. Install piping adjacent to equipment to allow service and maintenance.

3.2 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

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Hubless, cast-iron soil pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe fittings.

1.2 ACTION SUBMITTALS

A. Product Data:
1. Hubless, cast-iron soil pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe fittings.

1.3 INFORMATIONAL SUBMITTALS

A. 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 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.

2.2 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 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Charlotte Pipe and Foundry Company.
2. 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.

C. Standard, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ANACO-Husky.
b. Charlotte Pipe and Foundry Company.
c. Mission Rubber Company, LLC; a division of MCP Industries.
d. Tyler Pipe; a subsidiary of McWane Inc.

2. Marked with CISPI collective trademark and NSF certification mark.
3. Standards: ASTM C1277 and CISPI 310.
4. Description: Stainless steel corrugated shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

D. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ANACO-Husky.
b. Charlotte Pipe and Foundry Company.
c. Mission Rubber Company, LLC; a division of MCP Industries.

2. Standard: ASTM C1277 or ASTM C1540.
3. Description: Stainless steel shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.4 PVC PIPE AND FITTINGS

A. PVC Pipe:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Charlotte Pipe and Foundry Company.
b. National Pipe and Plastic, Inc.
c. North America Pipe Corporation.

2. NSF Marking: Comply with NSF 14 for plastic piping components. Include marking with "NSF-DWV" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.
3. Solid-Wall PVC Pipe: ASTM D2665 drain, waste, and vent.

4. NSF Marking: Comply with NSF 14 for plastic piping components. Include marking with "NSF-DWV" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.

B. Adhesive Primer: ASTM F656.

C. Solvent Cement: ASTM D2564.

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) Fernco Inc.
3) 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) Fernco Inc.
3) 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.

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. 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.

L. 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.

M. 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.

N. 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."

O. Install underground PVC piping in accordance with ASTM D2321.

P. Plumbing Specialties:

1. Install cleanouts in storm drainage gravity-flow piping in accessible locations.
   a. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."

2. Install drains in storm drainage gravity-flow piping.

   a. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

R. 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."

S. 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."

T. 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. 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.

B. 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.

C. Plastic, Nonpressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.

2. PVC Piping: Join in accordance with ASTM D2855 and ASTM D2665 appendices.

D. 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: Unshielded Shielded, nonpressure transition couplings.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. 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 carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Install stainless steel pipe support clamps for vertical piping in corrosive environments.
4. Vertical Piping: MSS Type 8 or Type 42, clamps.
5. 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.

6. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
7. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for cast-iron 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.

C. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

D. Support vertical cast-iron 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.

E. Support vertical PVC piping with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 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. 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.

3.7 IDENTIFICATION

A. Identify exposed storm drainage piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.8 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 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.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

3.10 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.

3.11 PIPING SCHEDULE

A. Aboveground storm drainage piping NPS 6 and smaller is to be the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI, hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

B. Aboveground, storm drainage piping NPS 8 and larger is to be the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI, hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

C. Underground storm drainage piping NPS 6 and smaller is to be the following:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
   2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Underground, storm drainage piping NPS 8 and larger is to be any of the following:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
   2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 221414

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-purpose roof drains.
2. Cleanouts.

B. Related Requirements:

1. Section 076200 "Sheet Metal Flashing and Trim" for penetrations of roofs.
2. Section 078413 "Penetration Firestopping" for firestopping roof penetrations.

1.2 ACTION SUBMITTALS

A. Product Data:

1. General-purpose roof drains.

2. Cleanouts.

1.3 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) Jay R. Smith Mfg Co; a division of Morris Group International.
2) WATTS; A Watts Water Technologies Company.
3) Zurn Industries, LLC.
4) Mifab.
5) Sioux Chief.

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) Extension collars.
    2) Underdeck clamp.
    3) Sump receiver plate.
    4) Water External Dam: 2 inches high. For overflow drains.

2.2 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) Jay R. Smith Mfg Co; a division of Morris Group International.
    2) WATTS; A Watts Water Technologies Company.
    3) Zurn Industries, LLC.
    4) Mifab.
    5) Sioux Chief.
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, plastic 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) Jay R. Smith Mfg Co; a division of Morris Group International.
    2) WATTS; A Watts Water Technologies Company.
    3) Zurn Industries, LLC.
    4) Mifab.
    5) Sioux Chief.
b. Standard: ASME A112.36.2M.
c. Size: Same as connected branch.
d. Type: Adjustable housing.
e. Body or Ferrule: Cast iron.
f. Outlet Connection: No-hub.
g. Closure: Plastic plug.

h. Adjustable Housing Material: Cast iron with setscrews or other device.
i. Frame and Cover Material and Finish: Nickel-bronze, copper alloy Painted cast iron.
j. Frame and Cover Shape: Round.
k. Top Loading Classification: Heavy Duty.
l. Riser: ASTM A74, Service Class, cast-iron drainage pipe fitting and riser to cleanout.

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) WATTS; A Watts Water Technologies Company.
3) Zurn Industries, LLC.
4) Mifab.
5) Sioux Chief.

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: Brass.
2) Head: Countersunk.
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.

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 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.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install test tees in vertical conductors and near floor.

F. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

G. 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

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial lavatories.
2. Commercial sinks.
3. Commercial urinals.
4. Commercial water closets.
5. Commercial Showers
6. Flushometer valves.
7. Toilet seats.
8. Fixture carriers.

B. Related Requirements:

1.2 ACTION SUBMITTALS

A. Product data.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted sinks.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Lavatory faucets, sink faucets and shower valves 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 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

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.

2.2 COMMERCIAL LAVATORIES

A. Lavatories, Wall Mounted:

1. Lavatories, Wall Mounted - Vitreous China, Rectangular with Back:

a. Manufacturers:
1) American Standard.
2) Kohler
3) Sloan.

b. Fixture:

1) Standard: ASME A112.19.2/CSA B45.1.
2) Type: For wall hanging.
3) Nominal Size: Rectangular, 20 by 18 inches.
4) Faucet-Hole Punching: Three hole .
5) Faucet-Hole Location: Top.
6) Color: White.
7) Mounting Material: Chair carrier.

c. Support: Lavatory carrier, floor affixed with steel uprights concealed arm.

B. Lavatory Faucets, Manually Operated:

a. Manufacturers:
1) Chicago Faucet.
2) T&S Brass.
3) Delta Faucet.

2. Standard: ASME A112.18.1/CSA B125.1.
3. Operation Type: Two handle, mixing, Commercial.
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
5. Body Type: Centerset.
6. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
7. Finish: Polished chrome plate.
8. Maximum Flow Rate: 0.5 gpm.
9. Mounting Type: Deck, exposed.
10. Spout: Rigid type.
11. Spout Outlet: Aerator.
12. Operation: Noncompression, manual.
13. Drain: Not part of faucet.

C. Lavatory Supply Fittings:

1. NSF Standard: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
2. Standard: ASME A112.18.1/CSA B125.1.
3. 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.
4. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

5. Operation: Loose key.
6. Risers:

    a. NPS 3/8.
    b. ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel, flexible hose riser.

D. Lavatory Waste Fittings:

1. Standard: ASME A112.18.2/CSA B125.2.
2. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.
3. Trap:

    a. Size: NPS 1-1/4.
    b. Material:

        1) 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.

E. Lavatory System:
1. Lavatory Systems - Multiple Stations:
    a. Manufacturers:
        1) Bradley.
        2) Sloan.
    b. Source Limitations: Obtain lavatory systems from single source from single manufacturer.
    c. Standards:
        1) ASME A112.18.1/CSA B125.1.
        2) CSA B45.5/IAPMO Z124.
        3) NSF 61.
        4) NSF 372.
        5) UPC, IPC, and GREENGUARD Certified.
    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. Bowl(s) and Counter:
        1) Material: Solid-surface or natural quartz surface.
        2) Height to Rim: Accessible in accordance with ICC A117.1.
        3) Color or Finish: Color as selected by architect.
        4) Access Panel: 16-1/8-inch access panel.
        5) Number of Bowls or User Stations: 2 and 3 station, see Schedule.
        6) Drain: Grid with NPS 1-1/2 tailpiece, each bowl.
    f. Faucets:
        1) Type: Manufacturer's standard, each bowl/station.
        2) Control: Hardwired, control-voltage, sensor-actuated actuation.
    g. Mounting: Manufacturer's wall-mounting bracket.
    h. Supply Fittings:
        1) Piping: NPS 1/2 copper tubing, each bowl.
        2) Valves: Shutoff valve on each supply.
        3) Supply Piping: From wall.
    i. Waste Fittings:
        1) Standard: ASME A112.18.2/CSA B125.2.
        2) Trap and Drain Piping: NPS 1-1/2, each bowl.

2.3 COMMERCIAL SHOWERS

1. Shower Valve Assemblies – ADA Compliant Single-Handle, Pressure-Balancing Mixing Valve with Standard Head and Hand Held Head : SH-2

    a. Manufacturers:
        1) Symmons.
        2) Powers.
        3) Leonard.
        4) Bradley.
    b. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.
    c. Description: Single-handle, accessible, pressure-balancing mixing valve with hot- and cold-water indicators; diverting valve check stops; and hose with handheld shower head on sliding rod shower head.
    d. Shower Valve:

        1) Standards:

            a) ASME A112.18.1/CSA B125.1.
            b) ASSE 1016/ASME A112.1016/CSA B125.16.

        2) Body Material: Solid brass.
        3) Finish: Polished chrome plate.
        4) Mounting: Concealed.
        5) Operation: Single-handle, twist or rotate control.
        6) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

    e. Supply Connections: NPS 1/2.
    f. Shower Head:

        1) Standard: ASME A112.18.1/CSA B125.1.
        2) Type: Ball joint with arm and flange.
        3)

2. Shower Valve Assemblies – Single-Handle, Pressure-Balancing Mixing Valve with Standard Head : SH-1

    a. Manufacturers:
        1) Symmons.
        2) Powers.
        3) Leonard.
        4) Bradley.
    b. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.
    c. Description: Single-handle, pressure-balancing mixing valve with hot- and cold-water indicators; check stops; and standard shower head.

d. Shower Valve:

1) Standards:

a) ASME A112.18.1/CSA B125.1.
b) ASSE 1016/ASME A112.1016/CSA B125.16.

2) Body Material: Solid brass.
3) Finish: Polished chrome plate.
4) Mounting: Concealed.
5) Operation: Single-handle, twist or rotate control.
6) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

e. Supply Connections: NPS 1/2.
f. Shower Head:

1) Standard: ASME A112.18.1/CSA B125.1.
2) Type: Ball joint with arm and flange.

2.4 COMMERCIAL SINKS

1. Service Sinks, Floor Mounted – Molded Stone: MB-1

a. Manufacturers:
1) Zurn.
2) Fiat.
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:

1) Standard: CSA B45.5/IAPMO Z124.
2) Material: Molded polymer.
3) Nominal Size: 24 by 24 by 10 inches.
4) Stainless Steel Rim Guard: On all top surfaces.
5) Drain: Grid with NPS 3 outlet.

d. Mounting: On floor and flush to wall.
e. Faucet: See Equipment Schedule on the contract drawings.

B. Sink: SK-1

1. Sink, Counter Mounted - Stainless Steel:

a. Manufacturers:
1) Elkay.
2) Just Manufacturing.
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:

1) Standard: ASME A112.19.3/CSA B45.4.
2) Type: Stainless steel, self-rimming, sound-deadened unit with ledge back.
3) Number of Compartments: See schedule.
4) Material: 18 gauge, Type 304 stainless steel.
   a) Drain: NPS 2 tailpiece and removable stainless steel cup strainer.

d. Supply Fittings:

1) Standard: ASME A112.18.1/CSA B125.1.
2) Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.

   a) Operation: Wheel handle.
   b) Risers: NPS 1/2, ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose.

e. Waste Fittings:

1) Standard: ASME A112.18.2/CSA B125.2.
2) Trap(s) Size: NPS 2.
3) Trap(s) Material:

   a) Chrome-plated, two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall; and chrome-plated brass or steel wall flange.

f. Mounting: On counter with sealant.

C. Sink Faucets, Manually Operated:

1. Sink Faucets, Manually Operated

a. Manufacturers:
   1) Chicago Faucet.
   2) T & S Brass.
   3) Delta Faucet
b. Source Limitations: Obtain sink faucets from single source from single manufacturer.
c. Standards:

   1) ASME A112.18.1/CSA B125.1.
   2) NSF 61.
   3) NSF 372.

d. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
e. Body Type: Widespread.
f. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
g. Finish: Chrome plated.
h. Maximum Flow Rate: 1.5 gpm.

i. Mounting Type: Deck, concealed.
j. Valve Handle(s): ADA compliant 2-1/2" lever handles.
k. Spout Type: See schedule.
l. Spout Outlet: Aerator.

2. Sink Faucets, Manually Operated – Mop Basin (MB-1):
   1) Manufacturers:
      a) Chicago Faucet.
      b) T & S Brass.
   b. Source Limitations: Obtain sink faucets from single source from single manufacturer.
   c. Description: Wall/back mounted, brass body, with integral service stops, checks, spout with bucket/pail hook, 3/4-inch hose thread end, integral vacuum breaker, inlets 8 inches o.c., and two-handle mixing.
   d. Faucet:
      1) Standards:
         a) ASME A112.18.1/CSA B125.1.
         b) NSF 61 and NSF 372.
         c) ICC A117.1.
         d) ASSE 1001 (VB).
      2) Finish: Rough chrome plated.
      3) Handles: Lever.
      4) Cartridges: One-fourth turn compression Ceramic.
      5) Brace: Adjustable top brace.
   e. Vacuum Breaker: Required for hose outlet.
   f. Spout Outlet: Hose thread in accordance with ASME B1.20.7.

2.5 COMMERCIAL URINALS

A. Urinals, Wall Hung: UR-1 and UR-2

1. Urinals, Wall Hung - Back Outlet, Siphon Jet :
   1) Manufacturers:
      a) American Standard.
      b) Kohler.
      c) Sloan.
   b. Fixture:
      1) Standards:
         a) ASME A112.19.2/CSA B45.1.
         b) ASME A112.19.5/CSA B45.15.
      2) Material: Vitreous china.
      3) Type: Washout.
      4) Water Consumption: 1.0 gpf.

5) Spud Size and Location: NPS 3/4; top.
6) Outlet Size and Location: NPS 2; back.
7) Color: White.

c. Waste Fitting:

1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
2) Size: NPS 2.

d. Support: Urinal carrier, floor affixed with steel uprights with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.

2.6 COMMERCIAL WATER CLOSETS

A. Water Closets, Wall Mounted: WC-1 and WC-2

1. Water Closets, Wall Mounted- Top Spud:

a. Manufacturers:
1) American Standard.
2) Kohler.
3) Sloan.

b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:

1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Rim Contour: Elongated.
5) Water Consumption: 1.6 gal. per flush.
6) Spud Size and Location: NPS 1-1/2; top.
7) Color: White.

e. Support: Water-closet carrier, floor affixed.

2.7 FLUSHOMETER VALVES

A. Flushometer Valves for Water Closet, Manual Operated:

1. Flushometer Valves, Manual Operated - Diaphragm

a. Manufacturers:
1) Sloan.
2) Zurn.

b. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
c. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
d. Minimum Pressure Rating: 125 psig.
e. Features: Include integral check stop and backflow-prevention device.
f. Material: Brass body with corrosion-resistant components.

g. Style: Exposed.
h. Exposed Flushometer-Valve Finish: Chrome-plated.
i. Actuator: Side mounted.
j. Consumption: 1.6 gal. per flush.
k. Minimum Inlet: NPS 1.

B. Flushometer Valves for Urinals- Diaphragm:

1. Flushometer Valves Water Closet - Diaphragm:

a. Manucafturers:
1) Sloan.
2) Zurn.
b. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
c. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
d. Minimum Pressure Rating: 125 psig.
e. Features: Include integral check stop and backflow-prevention device.
f. Material: Brass body with corrosion-resistant components.
g. Style: Exposed.
h. Actuator: Side mounted; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
i. Trip Mechanism: Consumption: . 1.0gal. per flush.
j. Minimum Inlet: NPS 3/4".

2.8 TOILET SEATS

A. Toilet Seats:

1. Manufacturers:
a. Bemis.
b. Church.
c. Centoco.
2. Source Limitations: Obtain toilet seat from single source from single manufacturer.
3. Standard: IAPMO/ANSI Z124.5.
4. Material: Plastic.
5. Type: Commercial (Heavy duty).
6. Shape: Elongated rim, open front.
7. Hinge: Self-sustaining, check.
8. Hinge Material: Noncorroding metal.
9. Seat Cover: Not required.
10. Color: White.

2.9 FIXTURE CARRIERS

A. Fixture Carriers - Lavatory

1. Manufacturers:

a. J.R. Smith.
b. Zurn.
c. Wade.
d. MIFAB.

2. Source Limitations: Obtain lavatory carriers from single source from single manufacturer.
3. Standards:

a. ASME A112.6.1M.
b. ASME A112.6.2.

B. Fixture Carriers - Urinal:
1. Source Limitations: Obtain urinal carriers from single source from single manufacturer.
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.

C. Fixture Carriers - Water Closet:
1. Source Limitations: Obtain water closet carriers from single source from single manufacturer.
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 INSTALLATION OF COMMERCIAL PLUMBING FIXTURES

A. Lavatory Installation:

1. Install lavatories level and plumb in accordance with roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-mounted lavatories.
3. Install accessible, wall-mounted lavatories at mounting height in accordance with ICC A117.1.
4. Install water-supply piping with stop on each supply to each lavatory faucet. Install stops in locations that are accessible for ease of operation.
5. Install trap and waste piping on each drain outlet of each lavatory to be connected to sanitary drainage system.
6. 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 220500 "Common Work Results for Plumbing."
7. 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."
8. 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."

B. Sink Installation:

1. Install sinks level and plumb in accordance with roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-mounted sinks.

3. Install water-supply piping with stop on each supply to each sink faucet.
   a. Install stops/valves in locations that are accessible for ease of operation.

4. Install trap and waste piping on each drain outlet of each sink to be connected to sanitary drainage system.
5. 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 220500 "Common Work Results for Plumbing."
6. Seal joints between sinks, 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."
7. 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."

C. Water Closet Installation:

1. Install water closets level and plumb in accordance with roughing-in drawings.
2. Install accessible, wall-mounted water closets at mounting height in accordance with ICC A117.1.
3. Use carrier supports with waste-fitting assembly and seal.
4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals, and affix to building substrate.
5. Measure support height installation from finished floor, not structural floor.
6. Install flushometer-valve, water-supply fitting on each supply to each water closet.
7. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
8. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
9. Install actuators in locations easily reachable for people with disabilities.
10. Install toilet seats on water closets.
11. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
12. Seal joints between water closets, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to water-closet color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.2 INSTALLATION OF PIPING CONNECTIONS

A. Connect plumbing fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match plumbing fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil, waste, and vent piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Install protective-shielding pipe covers and enclosures on exposed supplies and waste piping of accessible plumbing fixtures. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

E. Where installing piping adjacent to water closets and urinals, allow space for service and maintenance.

3.3 CLEANING AND PROTECTION

A. After completing installation of plumbing fixtures, inspect and repair damages finishes. Replace any fixtures unable to be repaired to the satisfaction of the Architect.

B. Clean plumbing fixtures and associated faucets, valves, flushometer valves, and fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed plumbing fixtures and associated faucets, valves, flushometer valves, and fittings.

D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224200

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. Pressure water coolers.
2. Bottle filling stations.
3. Supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pressure water cooler and bottle filling station.

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.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For pressure water coolers and bottle filling stations to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Pressure water coolers and bottle filling stations intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 or NSF 372, or be certified in compliance with NSF 61 or NSF 372 by an 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. Comply with ASHRAE 34 for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.

3. Comply with UL 399.
4. Comply with ASME A112.19.3/CSA B45.4.
5. 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.
6. Comply with NSF 42 and NSF 53 for water filters for water coolers and bottle filling stations.
7. Comply with ICC A117.1 for accessible water coolers and bottle filling stations.

2.2 PRESSURE WATER COOLERS

A. Pressure Water Coolers - Surface Wall-Mounted, Stainless Steel:

1. Manufacturers:
   a. Elkay.
   b. Halsey-Taylor.
   c. Oasis.
   d. Murdock Manufacturing.
2. Source Limitations: Obtain surface wall-mounted, stainless steel, pressure water coolers from single source from single manufacturer.
3. Type: Vandal resistant.
4. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
5. Control: Push bar
6. Bottle Filler: Sensor activation.
7. Drain: Grid with NPS 1-1/4 tailpiece.
8. Supply: NPS 3/8 with shutoff valve.
9. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
10. Filter: One or more water filters with capacity sized for unit peak flow rate.
11. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
12. Support: Water-cooler carrier.

2.3 SUPPORTS

A. Water-Cooler Carrier:

1. Manufacturers:
   a. Zurn.
   b. J. R. Smith.
   c. Wade.
2. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

C. Install mounting frames, affixed to building construction, and attach recessed, pressure water coolers, and bottle filling stations to mounting frames.

D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping.

E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between fixtures 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 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. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.6 CLEANING

A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224716

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 written expectations of general installation requirements.

1.3 DEFINITIONS

A. General Terminology:
1. Project A/E: Project Architect and/or Engineer of Record.
2. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
3. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
4. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
5. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
6. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
7. Project Documents: All documentation issued for bid and construction of described project. Documentation includes such items as Project Contracts, Project Schedules, Project Drawings, Project Specification, Requests for Information (RFI), Product Submittals, Test Reports, Start-Up Reports, Construction Change Directives (CCD), Proposal/Change Requests (PR, CR, CO, etc.), Close-Out Documentation, Operational and Maintenance Manuals, Warranty Documentation, etc.

1.4 QUALITY ASSURANCE

A. Confirmation of Site Conditions: Contractors are responsible to review the current on-site conditions to fully understand the access and space limitations for complete installations of new equipment and components. Submission of product and services confirms acceptance of responsibility to conform to the existing conditions.

B. General Requirements:
1. All deviations, such as cost, electrical power, physical space, operating conditions, between identified basis of design product and selected product shall be contractor’s responsibility to evaluate and therefore the contractor’s burden if added cost result.
2. Material and installation shall be compliant of governing and controlling regulations.
3. All materials used shall be new, of first-class quality and condition at installation.
4. Work done by Contractor shall include service of an experienced superintendent.
5. Steel Support Welding: Compliant of AWS D1.1, "Structural Welding Code--Steel."

6. Steel Pipe Welding: Compliant of ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   a. Compliant of ASME B31 Series, "Code for Pressure Piping."
   b. Each welder shall be certified by AWS qualification tests.
7. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics shall be considered, provided the proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified at no additional cost to the base contract.

1.5 CLOSEOUT

A. General Requirements; Refer to Division 01 for fully detailed listing of requirements.
   1. Remove all rubbish, unused tools, equipment and materials.
   2. Repair / repaint factory finishes with prime and finish coats where damaged exists.
   3. Clean equipment, permanent filters and exposed materials; replace disposable filters.
   4. Attic Stock: Deliver extra materials, such as filters, belts, thermometers, pressure gauges, control components etc., to Owner and obtain signed receipt(s) of delivery.
   5. Owner shall accept all conditions in writing prior to issuance of Substantial Completion.

B. FINAL COMPLETION
   1. All work shall be cleaned prior to issuance of Substantial Completion.
   2. Retouch or repaint factory painted prime and finish coats where damaged.
   3. Deliver filters, belts, and equipment, as required by this Specification, to Owner and obtained signed receipts of delivery.
   4. Clean equipment, repair damaged materials, and leave site in acceptable condition.
   5. Remove all installation tools, equipment, surplus materials, and rubbish from site.
   6. Contractor shall submit written certificates warranting each item of equipment.

C. RECORD DRAWINGS
   1. Record Drawings: Document each change and deviation from Original Project Drawings.
   2. Final Project Record Drawings shall be submitted to Project Design Engineer for approval at the completion of the project.
      a. Provide finished copy of record drawings to Test & Balance Contractor prior to commencement of test and balance of the building systems.
   3. Record Drawings shall include the location of concealed piping and ductwork.
   4. Final Project Record Drawings: Provide to A/E with Project Closeout Documents.

D. MAINTENANCE & OPERATING MANUALS
   1. The Maintenance and Operating Manuals shall comply with other Sections of this Specification. Submit in triplicate for inclusion in Maintenance and Operating Manuals.
      a. Provide bound hardcopies of operating instructions, reviewed shop drawings, equipment catalog data, warranties and manufacturer’s instructions.

E. WARRANTY
   1. Contractor shall warrant installation, including materials, devices, equipment and labor, for a continuous 1-year period after the documented Date of Substantial Completion.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS & CONDITIONS

A. Transport & Storage Requirements:
1. Deliver pipe and tube with factory-applied end caps. Maintain caps during shipment, storage and handling to prevent damage and dirt, debris and moisture infiltration.
2. Protect plastic pipes from direct sunlight. Support to prevent warping or bending.
3. All pipe, tube and equipment shall be elevated above grade during storage.
4. Store air-side equipment, duct and sheet metal accessories indoors, above floor. Materials stored outdoors may be rejected, as determined by determined by A/E.
5. Store insulation and insulation accessories indoors, above floor. Materials stored outdoors may be rejected, as determined by determined by A/E.
6. Air-handlers shall ship fully crated or wrapped by factory for protection from weather.
7. All air-side materials and equipment, such as duct, insulation, air-handlers, terminals units, coils, fans, heaters, duct and duct accessories shall be shipped, received and stored to prevent moisture damage, whether directly or to not prevent biological growth. Equipment and material that is found wet or having visible indication of having been wet may be rejected, as determined by determined by A/E.
8. Do not operate cold-air and -water systems prior to completion of insulation to avoid the accumulation on condensation, and subsequent damage to other building materials.

B. General Demolition Requirements:
1. Contractor is responsible for all work described within project documents – consisting of drawing sheets and project specifications. Contractor shall review existing conditions in person to attain sufficient knowledge of building conditions to provide a responsible bid for all foreseeable work. Contractor shall include costs of coordination with other trades and performance of work in conformance to project schedule. Where additional clarification is necessary due to deviation of existing conditions with project documentation and/or procured materials, seek resolution through Construction Manager prior to continuation of affected work.
2. Contractor is responsible to protect all building services, components and/or finishes that are to remain. Prior to commencement of work, contractor is responsible to identify existing damage that they will otherwise be responsible to repair. Documentation of existing damage shall be in writing to Construction Manager. Damage that occurs to new and/or existing services, components and /or finishes during periods of work shall be corrected at the expense of contractor.
3. Locations shown on the drawing sheets are diagrammatic to define scope of work and approximate locations of indicated HVAC equipment, duct, pipe, and/or other related components, devices, and materials. Unless specifically noted, precise installation conditions are the responsibility of the contractor to allow time efficient progression of work. Contractor is responsible to understand the extent of work, work of other trades, and equipment manufacturer installation and service limitation that affect position and orientation of HVAC equipment, components, devices, etc. at specific locations. Equipment not installed with reasonable and/or optimal access in consideration of the installation conditions shall be modified at the expense of the Contractor, if not otherwise determined reasonable by the Project Architect/Engineer. Commencement of work confirms contractors understanding and acceptance of working conditions.
4. Demolition: As indicated on Project Drawings within areas of renovation; all existing shown and un-shown HVAC equipment such as duct, pipe, power and controls devices and wiring, insulation, supports, and equipment pads shall be deconstructed as necessary to facilitate removal,

responsible and appropriated disposal by Contractor. Contractor is responsible for all fees and cost of removal of HVAC equipment, duct, pipe, and related materials from site.

5. Equipment Salvage: Where specifically identified, equipment shall be retained in its current operating condition, but removed from its current location and turned over to the owner at an owner designated location on site. Contractor confirm and coordinate the responsibility of all salvaged equipment prior to the commencement of work.
6. Penetrations: Wall, floor, and roof penetrations for existing HVAC components that are not specifically indicated for reuse shall be infilled and finished to match adjacent wall materials and construction. Refer to architectural sheets for additional infill and finish requirements.

C. General Installation Requirements:
1. Clarification of Scope of Work: Seek instruction from Construction Manager when necessary, as a result of document or present deviation(s).
2. Project Schedule: Contractor shall include costs of coordination with other trades and performance of their work in conformance to Project Schedule.
3. Contractor is responsible for work described within Project Documents, which is includes bid documentation and all documentation issued thereafter to fully describe the requirements for completion of this project.
4. Protection of Finishes: Contractor shall protect new, existing and temporary components, finishes and services during completion of work. Contractor shall identify existing damage; that will otherwise be their responsibility to repair or replace before work begins at location damage is discovered. Existing damage shall be documented to Construction Manager. Damage incurred by Contractor shall be corrected at Contractor's expense.
5. Installation Conditions: Location on these sheets are diagrammatic to define Scope of Work with an approximate indication of location/position of equipment, duct, pipe and other components, devices and materials relative to other new or existing components. Contractor is responsible for a complete installation in compliance with the Project Documents and is responsible to include the cost of minor installation offsets where necessary for a complete and coordinated installation. Although elevations may be identified on the project drawings, these indications are intended to provide general expectations from 2-dimensional plans. Contractor is responsible to identify final coordinated installation elevations relevant to noted elevations, and as identified in the Project Documents. Except where specifically indicated otherwise, the precise installation conditions, including work of other trades, are the contractor's responsibility to coordinate in a time efficient progression to complete work in compliance of Project Documents.
6. Coordination of Contractor Selected Product: Contractor is responsible to understand extent of work, including work of other trades, and selected material and equipment installation requirements, limitations and service clearances required by product manufacturer, project documents and code requirements. Equipment and device components requiring access shall include acceptable access, as determined by A/E. Contractor is responsible to install access to meet A/E expectations.
7. Installation Arrangement: Duct and pipe routing, equipment connection orientation and configuration, etc., are relatively specific in consideration to the system's friction loss calculated by the Project A/E. Contractor is expected to install equipment and materials in compliance to indicated positions, routes, fitting quantity and fitting type. Expected deviation to position, routes and fittings shall be brought to the attention of Project A/E for review with the Coordinated Drawing Set; all expected deviations shall be specifically clouded for identification. Document field installation deviations with a Request for Information to attain review and directive from Project A/E.
8. Basis of Design Equipment: Layout is manufacturer specific when a Basis of Design Manufacturer is identified in the Project Documents; a general equipment layout should be expected otherwise. Contractor is responsible to understand, coordinate and install to the requirements of the equipment being procured.

9. Equipment Information: In addition to Project Specifications, tagged equipment may also be identified with equipment schedules or drawings notes on Project Drawings. Information conveyed at all locations are expected for compliance; although redundant information is expected, not all information may be provided at a location, therefore, contractor is responsible to coordinate all information from all locations.
10. Typical Drawing Sheet Content: Contractor is responsible to coordinate work on all sheets for a complete and compliant installation; typically, not all of the information necessary for the complete installation is able to be conveyed in a single location within Project Documents.
11. Installation Identification: Installation shall comply with Section 230553.

D. Equipment with Connecting Duct System Requirements:
1. Duct Take-Off Connectors:
    1) Low-pressure Supply-Air Duct:
        a) Round Strait Tap: 90- or 45- degree take-off fittings.
        b) Rectangular Strait Tap: 45-degree style.
        c) Rectangular Shoe Tap: 90-degree with integral 45-degree entry.
    2) Exhaust-Air Duct:
        a) Round Strait Tap: 45-degree style.
        b) Round Lo-Loss Tap: 90-degree with integral 45-degree entry.
        c) Rectangular Strait Tap: 45-degree style.
        d) Rectangular (Shoe) Tap: 90-degree with integral 45-degree entry.
2. Duct Size: Supply duct and fittings shall be sized to nearest indicated upstream mainline size, with transitions taking place downstream of nearest upstream branch; conversely, exhaust and return duct and fittings shall be sized to nearest indicated downstream mainline size, with transitions taking place upstream of nearest downstream branch.
3. Wall Escutcheon: Penetrations through exposed walls shall be covered with a contractor fabricated 2-piece sheet metal escutcheon constructed of not less than 20-gauge galvanized sheet metal; finish matching adjacent wall area.
4. Wall Penetration: Install metal sleeves though wall penetrations consisting of non-uniform materials and fire-caulking or smoke-barrier material(s) where necessary; refer to Architectural Sheets and Project Specifications for rated-wall requirements.
5. Fire Dampers: Type-B, unless otherwise indicated. Install Fire, smoke and combination damper with duct mounted access panel to allow visual of damper position and component access. Refer to Section 233300 for damper and access requirements.
6. Flexible Duct: Required for transition from rigid duct to ceiling mounted air devices, as indicated on Project Drawings. Flexible duct shall be 6- to 8-feet in length; support in compliance of manufacturer's and SMACNA recommendations. Bending radius shall be no less than 1.5 times diameter. Refer to Section 233300 for flexible duct requirements.
7. Return Wall Openings (RWO): RWO shall be located above adjacent ceiling(s).
    1) Unprotected Openings: Wall openings where duct, pipe, conduit, etc. may pass if opening is enlarged to allow for indicated minimum free area.
    2) Protected Openings: Wall opening is protected with fire, smoke or combination damper; operation of damper shall not be obstructed.
    3) Location: Openings are expected to be installed as high as is possible in consideration of the above structure and deck elevations but do need to be coordinated with other trades. Although the location of these openings may be located for ease of identification on the Project Drawings, typically there is some flexibility for the positioning of these openings, however the installer does need to locate these openings to minimize noise transmission between the connected spaces, please consider the following conditions:

a) Locating openings as high as possible and using building structure and wall bond beams in lieu of otherwise possibly requiring a dedicated lintel are preferred, where applicable.
b) Locating unprotected return wall openings that include the passage of duct, pipes, conduit, etc. do actually provide benefit; these types of materials do typically provide diffusion to noise that would otherwise simply pass though an opening. The important consideration is that the opening size shown on the drawings is the minimum free area that needs to be available within the final constructed opening, unless the otherwise noted with installation passage through the identified opening.
c) Locating return wall openings above services passing through or adjacent to openings is preferred, these materials will mask noise that would otherwise be able to pass directly though the opening.
d) Typically wall and deck/roof structure may remain or pass through these openings, although for a stud wall it may be just as easy to frame out the opening. The opening size does need to be enlarged to include the space occupied by obstructions within the opening.
e) Locating near above doorways are preferred in spaces that lack other the otherwise opportune conditions noted above, doorways are typically the least acoustically sensitive, and the least acoustically protected locations within a room, due to the doorway itself.
f) For convenience where large portions of walls are intended to remain open, building services may be shown passing thorough a return wall opening, these openings can not and should not be larger than the space that is available above the intended ceiling elevation.

8. Ceiling Air Devices: Contractor shall coordinate ceiling mounted devices with ceiling layout, and work of other trades requiring ceiling mounted devices.
9. Visible Duct: Bare and insulated duct installed through exposed areas shall be assumed painted, unless otherwise indicated. Clean and prepare duct or insulation for finishing, coordinating work with other trades.

E. Equipment with Connecting Pipe System Installation Requirements:
1. Hydronic System Air Management: Pipe mains shall be installed above coil installation elevations, typical. Contractor is responsible to install manual drains at low point and air-vents at high point locations of hydronic systems to facilitate system draining and refill. Valves shall be at visible and accessible at exposed locations and through ceiling access.
2. Pipe Sizing: Supply pipe and fittings shall be sized to nearest indicated upstream mainline size, with transition downstream of nearest upstream branch; conversely, return pipe and fittings shall be sized to nearest indicated downstream mainline size with transition upstream of nearest downstream branch.
3. Wall Escutcheons: Visible wall penetrations shall be covered with a metal escutcheon; escutcheon shall be as identified in Section 232113.
4. Wall Penetrations: Install metal sleeves though wall penetrations consisting of non-uniform materials and fire-caulking or smoke-barrier material(s) where necessary; refer to Architectural Sheets and Project Specifications for rated-wall requirements.
5. Pipe-Tee Flow Orientation: Installation of bullhead or diverging flow tee fitting is unacceptable, unless otherwise specifically indicated. Typically, tee fitting shall only be utilized to accommodate branch flow; branch flow shall allow for flow minority while mainline flow accommodates flow majority.

6. Hydronic System Cleaning: Contractor is responsible to thoroughly clean and flush hydronic systems prior to final fill and adding chemical treatment product(s). Refer to Section 232500 for cleaning, flushing and chemical treatment requirements.

F. Equipment with Connecting Electronic System Requirements
1. Devices: Install electronic comfort control devices and sensors, such as but not limited to local multifunction controllers, temperature, humidity, carbon dioxide (CO2) and pressure sensors, as indicated on the Project Documents. If a necessary control device location is not found on the Project Drawings that is identified, seek clarification for device location; device is required. Wall mounted sensors shall be installed with flush-mounted wall boxes, with wires installed within wall. Combination shall be utilized where indicated. Refer to Section 230900 for device specific requirements.
2. Low-voltage Power: Wire and/or cabling required for successful functional operation of Temperature Control System as described by Section 230993, and equipment specific Sections, is responsibility of contractor to include in base contract.
3. Control Device Power Wiring: Wiring and/or cabling required to power control devices is the responsibility of the contractor to include in the base contract.
4. Temperature Control Panels: Control panels for outdoor equipment shall be located within building; preferred may be indicated on Project Drawings. Contractor is responsible to coordinate size, quantity and locations with other trade.
5. Communication Access Points: Contractor shall coordinate with other trades to assign hardware and software access points for Division 23 equipment.
6. Temperature Control System Server: Install Temperature Control Server in Mainframe Room server rack, install custodian desktop computer in Custodial Office.

G. Other Control Instrumentation and Operational Sequencing Coordination for Implementation
1. Replacement of this building heating and/or cooling plants is currently under contract for completion with the same funding source. To allow for consistency of the temperature control systems within each building, the contract awarded with this project shall require coordination and implementation of control hardware and software for the complete control of all Division 23 equipment identified in both contracts with a single uniform and integrated Temperature Control System.

H. Roof Penetrations
1. Roof deck edges at new penetrations shall be reinforced with angle iron at each edge, with connection to the existing adjacent structure at a minimum of four points.
2. Approved Roofing Contractors: Work shall be performed by an owner approved roofing contractor for modifications and repairs to existing roofing. Coordinate all work with other trades for a complete, thorough, and weather tight installation.
    a. Roof work includes removal of existing roofing materials down to existing roof deck and installation of new materials for tie-in/flashing to the existing roofing after installation of new roof top equipment. Only remove minimum amount of existing roofing materials for new equipment and materials installation(s).
        1) Provide new roofing materials that are equivalent and compatible with existing roofing, application, and service.
            a) In visual observation, the existing roofing materials appeared to be of different types at the installation locations, EPDM membrane, ballasted EPDM membrane, or built-up roofing.
            b) Existing roofing materials are no longer under warranty.
            c) Ensure minimum roof flashing height of 8 inches above adjacent roof is maintained with new equipment assembly.

d) Insulation and substrate materials shall match existing composition and thickness. Provide deck board if existing, vapor barrier, and cover board if part of existing assembly.

e) Flexible sheet roofing system and flashings shall match existing material and thickness. Provide bonding adhesives, splicing cement, cleaners, seam sealer, primers and sealants as recommended by the roofing manufacturer for the application and substrates.

f) If required to match existing, provide Asphalt impregnated fiberglass sheets, Type IV, for base sheet and flashings. Provide interply sheets and cap sheets as required to match existing. Utilize cold-applied adhesive as required by roofing manufacturer.

g) Terminate new membrane on vertical portions of new equipment curb with termination bar and sealant. Where metal counterflashing is required, provide formed aluminum flashings, 0.040 inch thick, mill finish.

h) Clean existing roof surface surrounding new equipment as recommended by manufacturer to achieve proper adhesion and sealing of new materials to existing surface.

i) Provide complete weathertight installation with manufacturer's recommended new to existing detail with bonding adhesives, splicing cement, seam sealer, and sealants.

I. Concrete Equipment Pads
   1. Concrete slab on grade with reinforcing as indicted. Exterior concrete shall be
   2. 4500 PSI at 28 days, max w/c ratio equal to 0.45, mid-range water reducer, air content 5%, with a tolerance of +/- 1.5%, at point of deliver. Maximum 0.75-inch aggregate size. Comply with ACI 301 "Specification for Structural Concrete," normal weight concrete. Interior concrete shall be 4000 PSI at 28 days, max w/c ratio equal to 0.45, mid-range water reducer, slump limit of 4 inches, with a tolerance of +/-1-inch, before adding water-reducing or plasticizing admixture. Do note use high range water reducers. Air content not to exceed 3%. Comply with ACI 301 "Specification for Structural Concrete," normal weight concrete.

3.2 PAINTING

A. General Requirements:
   1. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

END OF SECTION 230500

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.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) 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: Separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. 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.

J. 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 Controller:

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.

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.

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 230513

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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 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

PART 2 - PRODUCTS

2.1 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: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
3. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.2 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.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi 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.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. 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: Zinc-coated steel.
   2. Outdoor Applications: Stainless steel.

2.5 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.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes with spring isolators.

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; galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink, and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. 078413Strength 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 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.

B. Thermal-Hanger Shield Installation: Install on pipe hanger or shield for insulated piping.

C. Fastener System Installation:

1. Install 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 mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

D. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

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.

J. 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.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands with spring isolators 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.

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 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 finish.

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 metal trapeze pipe hangers and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. 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.

J. 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.

K. 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.

L. 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.

M. 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.

N. 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. 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.
4. 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.

O. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system 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

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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- 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 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.

C. Delegated Design Submittals:

1. For each seismic-restraint device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, concrete anchor and insert, and restrained isolation roof-curb rail that is required by this Section or is indicated on Drawings, submit the following:

    a. Seismic Restraint, and Vibration Isolation Base Selection: Select vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
    b. 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 by professional engineer that riser system was examined for excessive stress and that none exists.
    c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
    d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
    e. Qualified Professional Engineer: All designated-design submittals for seismic- and wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.
2. Seismic- Restraint Detail Drawing:

    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 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 also with requirements in other Sections for equipment mounted outdoors.

3. All delegated design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
4. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and basis for approval (tests or calculations).
5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

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.

C. Welding certificates.

D. Field quality-control reports.

E. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in 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 (AHRI 1271), including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction 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 7-16.
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
4. The following HVAC systems and components are Designated Seismic Systems and require written special certification of seismic qualification by manufacturer:

1.5 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: an agency acceptable to authorities having jurisdiction.

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 load control system.
   1. Seismic Performance: Equipment to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7-16.

B. 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 7-16 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. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
      c. Building Risk Category: III.
      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: Per ASCE/SEI 7-16 Section 11.4.5. 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 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: Per ASCE/SEI 7-10 Section 11.5.1. 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 fps^2.

3) K_p = Combined Stiffness of Component, Supports, and Attachments: Determined by delegated design seismic engineer..

C. 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 7-16 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.

D. 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.

E. 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/SEI 7-16 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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 or 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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 or 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

a. Amber/Booth Co.
b. Cooper B-Line, Inc.
c. Hilti North America.
d. MIRO Industries Inc.
e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

    a. Amber/Booth Co.
    b. Cooper B-Line, Inc.
    c. Hilti North America.
    d. MIRO Industries Inc.
    e. Seismic Control Products, LLC.
    f. Simpson Strong-Tie.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

    1. Amber/Booth Co.
    2. Cooper B-Line, Inc.
    3. Hilti North America.
    4. MIRO Industries Inc.
    5. Seismic Control Products, LLC.
    6. Simpson Strong-Tie.

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 318-11 Appendix D for 2012 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

1. Amber/Booth Co.
2. Cooper B-Line, Inc.
3. Hilti North America.
4. MIRO Industries Inc.
5. Seismic Control Products, LLC.
6. Simpson Strong-Tie.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

1. Amber/Booth Co.
2. Cooper B-Line, Inc.
3. Hilti North America.
4. MIRO Industries Inc.
5. Seismic Control Products, LLC.
6. Simpson Strong-Tie.

B. Source Limitations: Obtain cable-type restraints from single manufacturer.

C. Seismic-Restraint 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.

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, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

1. Amber/Booth Co.

2. Cooper B-Line, Inc.
3. Hilti North America.
4. MIRO Industries Inc.
5. Seismic Control Products, LLC.
6. Simpson Strong-Tie.

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 orReinforcing 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, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

   a. Amber/Booth Co.
   b. Cooper B-Line, Inc.
   c. Hilti North America.
   d. MIRO Industries Inc.
   e. Seismic Control Products, LLC.
   f. Simpson Strong-Tie.

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,:

   a. Amber/Booth Co.
   b. Cooper B-Line, Inc.
   c. Hilti North America.
   d. MIRO Industries Inc.

e. Seismic Control Products, LLC.
f. Simpson Strong-Tie.

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 7-16, 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, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

1. Amber/Booth Co.
2. Cooper B-Line, Inc.
3. Hilti North America.
4. MIRO Industries Inc.
5. Seismic Control Products, LLC.
6. Simpson Strong-Tie.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

1. Amber/Booth Co.
2. Cooper B-Line, Inc.

3. MIRO Industries Inc.
4. Seismic Control Products, LLC.

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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:

1. Amber/Booth Co.
2. Cooper B-Line, Inc.
3. MIRO Industries Inc.
4. Seismic Control Products, LLC.

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 (50 mm) 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 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-restraint devices 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 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 o.c., and longitudinal supports a maximum of 80 feet 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 the more stringent between SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems"or ASCE/SEI 7.
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.
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 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: 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

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Ceiling Markers.
3. Pipe labels.
4. Valve Tags.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Valve Schedules.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/2 inch.
6. Fasteners: Stainless steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

2.2 CEILING MARKERS

A. Plastic Engraved Ceiling Markers for T-Bar Ceiling Grid:
1. Material and Thickness: Multilayer, multicolor, plastic label for mechanical engraving, 1/16 inch thick, with self adhesive back for attachment to ceiling grid.
2. Letter and Background Color: As indicated for specific application under Part 3.

3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
4. Minimum Label Size: 2-1/2 inch by 3/4 inch.
5. Minimum Letter Size: 1/4 inch.
6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number or Valve Number.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

B. Letter and Background Color: As indicated for specific application under Part 3.

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. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: At least 1 inch.

2.4 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain or S-hook.

B. Letter and Background Color: As indicated for specific application under Part 3.

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. Include valve-tag schedule in operation and maintenance data.

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 INSTALLATION, GENERAL 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.

D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Sign and Label Colors:

1. White letters on an ANSI Z535.1 safety-blue background.

C. Locate equipment labels where accessible and visible.

3.4 INSTALLATION OF CEILING MARKERS

A. Permanently fasten labels to bottom of ceiling grid at location of all mechanical equipment above ceilings and at all locations of branch valves for all mechanical piping systems.

B. Sign and Label Colors:

1. Mechanical Equipment above ceilings: White letters on an ANSI Z535.1 safety-blue background.
2. Valves above ceilings: Black Letters on an ANSI Z535.1 safety-yellow background.

C. Locate equipment labels where accessible and visible from floor.

3.5 INSTALLATION OF PIPE LABELS

A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

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. Within 3 ft. of each valve and control device.
2. At access doors and similar access points that permit view of concealed piping.
3. Within 3 ft. of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.

C. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

D. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. Pipe-Label Color Schedule:

1. Chilled-Water Piping: White letters on an ANSI Z535.1 safety-green background.
2. Heating Water Piping: White letters on an ANSI Z535.1 safety-green background.

END OF SECTION 230553

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. Constant-volume air systems.
b. Variable-volume air systems.

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 INFORMATIONAL SUBMITTALS

A. Certified TAB reports.

B. 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.

1.5 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."

C. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

D. TAB Specialist: The Contractor shall utilize FLO-TECH to perform all testing and balancing. All costs are to be included in the Contractor's Base Bid amount. FLO-TECH, 10988 Ditney Hill Road, Elberfeld, IN 47613, Contact: Bob Letterman, Phone: 812-983-4348. No Substitutions.

E. Test and balance firm shall include an extended warranty of one year after completion of test and balance work, during which time the Architect/Engineer at his discretion may request a recheck or resetting of any outlet, supply air fan, or exhaust fans listed in test report. The firm shall provide technicians to assist the Architect/Engineer in making any tests the Architect/Engineer may require during this period of time.

1.6 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

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.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

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, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
4. 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) 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. Fans and ventilators.
3. Rooftop air-conditioning units.
4. Split-system air conditioners.
5. Terminal units.
6. Unit heaters.

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.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.

b. 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.
c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. 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 artificial loading of filters at the time static pressures are measured.

3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 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.

3.8 PROCEDURES FOR MOTORS

A. Motors ½ 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.

3.9 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.

3.10 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 or minus 10 percent. If design value is less than 100 cfm (47 L/s), within 10 cfm (4.7 L/s).
2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm (47 L/s), within 10 cfm (4.7 L/s).
3. Heating-Water Flow Rate: Plus or minus 10 percent. If design value is less than 10 gpm (0.63 L/s), within 10 percent.
4. Chilled-Water Flow Rate: Plus or minus 10 percent. If design value is less than 10 gpm (0.63 L/s), within 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 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. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. 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.

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 (mm), and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
    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 (mm), and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

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. 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 (mm), and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
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.

G. 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.

H. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

END OF SECTION 230593

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply.
2. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
3. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Related Sections:

1. Section 230719 "HVAC Piping Insulation."
2. Section 233113 "Metal Ducts" for duct liners.

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).

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program.

1.4 DELIVERY, STORAGE, AND HANDLING

1.5 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 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.

1.6 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.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor 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. 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.

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. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials are 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.

2.5 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.

2.6 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

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.

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. 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.

K. Cut insulation in a manner to avoid compressing insulation.

L. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

M. 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 Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

B. 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."

C. 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 AND MINERAL-WOOL 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 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

C. 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.

3.6 FIELD QUALITY CONTROL

A. 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 three location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Double-wall Ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation is the following:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density with FSK jacket.

B. Concealed, rectangular, supply-air duct insulation is the following:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density with FSK jacket.

END OF SECTION 230713

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Products Furnished but not Installed Under this Section
B. Products Installed but not Furnished under this Section
C. Products not Furnished or Installed under but Integrated with the Work of this Section
D. Related Sections
E. Spare Parts
F. Description
G. Approved Control System Primary Manufacturers
H. Quality Assurance
I. Codes and Standards
J. System Performance
K. Submittals
L. Warranty

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 232113 Hydronic Piping

1. Control Valves
2. Flow Switches
3. Temperature Sensor Wells and Sockets
4. Flow Meters

B. Section 232300 Refrigerant Piping Systems

1. Pressure and Temperature Sensor Wells and Sockets
2. Split system low voltage wiring.

C. Section 233300 Air Duct Accessories

1. Automatic Dampers
2. Airflow Stations
3. Terminal Unit Controls

D. Section 232923 Variable Frequency Motor Controllers
1. Section 230900 Contractor Provided Variable Frequency Drives

1.4 Products not furnished or installed but integrated into the controls work.

A. Division 23 Sections for Boiler Equipment

1. Boiler Controls

B. Division 23 Sections for Chiller Equipment

1. Chiller Controls

C. Division 23 Section for VAV Terminal Units

1. Cross-Flow Velocity Sensor

D. Division 26 Exterior Lighting Controls

2. Exterior lighting panel communication and scheduling by BMS

1.5 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:
1. Division 23 Sections for Common Work Results Mechanical
2. Division 23 Sections for Condensing Boilers
3. Division 23 Sections for Air-Cooled Chillers
4. Division 23 Sections for Metal Ducts
5. Division 23 Section for Testing, Adjusting, and Balancing
6. Division 26 Sections for Basic Electrical Materials and Methods
7. Division 26 Sections for Wiring Methods
8. Division 26 Sections for Electrical Power
9. Division 26 Sections for Low-Voltage Distribution
10. Division 26 Sections Exterior Lighting Panels

1.6 REQUIRED SPARE PARTS

A. Controllers:

1. Two (2) spare controllers for each unique controller (custom application and application specific controller) provided for the project including but not limited to VAV controllers, AHU controllers and central plant controllers.

1.7 DESCRIPTION

A. Full Web-based Interface:

1. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and an operator workstation. This contractor shall leverage existing server environment or provide new as required to create a web-based operator workstation and workstation software installed on the server for programming, alarms, trending, and other required configuration tools.
2. System software and firmware shall be based on the open standards of web technology. The control system server shall be accessed using a web browser over the control system network, the Owner's local area network, and remotely over the Internet through the Owner's LAN.
3. The intent of the thin-client architecture is to provide operators complete access to the control system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming.
4. Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.
5. Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.

1.8 APPROVED CONTROL SYSTEM PRIMARY MANUFACTURERS

A. The following are approved control system manufacturers and product lines

Manufacturer	**Product Line**
Manufacturer A	Automated Logic installed by Indiana Carrier branch office only
Manufacturer B	Alerton Controls by OCS Indianapolis

1. Control systems shall comply with the terms of this specification and follow all other Construction Documents.
2. Use operator workstation software, controller firmware, custom application programming language, building controllers, custom application controllers, and application specific controllers shall be from one of the manufacturers and product lines listed.
3. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.
4. If Contractor believes there are conflicts or missing information in the Construction Documents, Contractor shall request clarification from the Engineer prior to bid.

1.9 QUALITY ASSURANCE

A. Controls installation contractor and Manufacturer Qualifications

B. The controls installation contractor shall have an established working relationship with BAS Manufacturer of not less than three years.

C. The controls installation contractor shall have successfully completed BAS control system training.

D. Contractor shall comply with the workplace safety requirements and once identified, eliminate all hazards before any further work proceeds. Report all hazards observed within twenty four hours to the mechanical contractor, and the Owner.

1.10 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes, where applicable:

1. National Electric Code (NEC)
2. International Building Code (IBC)
3. International Mechanical Code (IMC)
4. National Fire Protection Association (NFPA) 70, 90A-Standard for the Installation of Air Conditioning and Ventilating Systems, 92A,92B-Smoke Purge/Control Equipment, and 90B Standards
5. Underwriters Laboratories listing and labels (UL)- 504-Industrial Control Equipment, UL 506-Specialty Transformers, UL 864-Smoke Control, UL 268-Smoke Detectors, UL 910-Test Method for Fire and Smoke Characteristics, UL 916-Energy Management, UL 1449-Transient Voltage Suppression
6. American Society of Heating, Refrigerating and Air Conditioning Engineers - ASHRAE 135.2012 and ASHRAE 36-2018 and ASHRAE 13-2015
7. Electronics Industries Association - EIA 232-E, 455
8. Occupational Safety and Health Administration (OSHA)
9. Federal Communications Commission (FCC) including part 15-Radio Frequency Devices and Part 15-Subpart J-Class A Computing Devices
10. Americans Disability Act (ADA)
11. ANSI/ASHRAE Standard 195-2004 (BACnet) and SSPC-135
12. Institute of Electrical and Electronic Engineers (IEEE) - C62.41, 142
13. American Standard Code for Information Interchange (ASCII)
14. Uniform Building Code (UBC) - Section 608-Shutoff for Smoke Control, Section 403.3-Smoke Detection Group B Office Buildings and Group R Division 1 Occupancies, Section 710.5-Wiring in Plenums, Section 713.10-Smoke Dampers, Section 1106 Refrigeration Machinery Rooms, Section 1107-Refrigeration Machinery Room Ventilation, Section 1108-Refrigeration Machinery Room Equipment and Controls, Section 1120-Detection and Alarm Systems

1.11 BAS PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections:

B. Graphic Display. A graphic with 20 dynamic points shall display valid data within 10 seconds.

C. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 seconds.

D. Object Command. Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds. Do not rely upon non-local points and BACnet MSTP communication to control equipment commands.

E. Object Scan. Data used or displayed at a controller or workstation shall have been current within the previous 6 seconds.

F. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 seconds.

G. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with the mechanical process under control.

H. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.

I. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 seconds of other workstations.

J. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.

K. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 1 under "Accuracy Required for Control."

L. The BMS as provided shall incorporate, at minimum, the following integrated features, functions, and services:

1. Operator information, alarm management, and control functions.
2. Enterprise-level information and control access.
3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
4. Diagnostic monitoring and reporting of BMS functions.
5. Offsite monitoring and reporting of BMS functions.
6. Energy management.
7. Standard ASHRAE based applications for terminal HVAC systems.
8. CO2 monitoring and demand control ventilation with control as specified.
9. Temperature and humidity monitoring with control as specified.
10. Utility meters monitoring, display and trending.

1.12 ACTION SUBMITTALS

A. Product Data, Shop Drawings, and Schedules:

1. Product Data and Shop Drawings:

a. Meet requirements of Division 01 Section on Shop Drawings, Product Data, and Samples. In addition, Contractor shall provide shop drawings or other submittals on all hardware, software, and installation to be provided. No work may begin on any segment of this project until submittals have been successfully reviewed and approved for conformity with the design intent. Three physical copies are required. Provide drawings to Owner and engineer as files on optical disk or USB flash drive (file format: .dwg, .dxf, .vsd, or comparable) with three 11" x 17" prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Submittals shall be provided within 12 weeks of contract award. Submittals shall include:

b. BAS Hardware:

1) A complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data.

2) Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for the items listed below and other relevant items not listed below:

a) DDC (controller panels)
b) Transducers/Transmitters
c) Sensors (including accuracy data)
d) Actuators
e) Valve Assemblies in schedule format
f) Dampers Assemblies in schedule format
g) Airflow measuring stations in schedule format
h) Variable frequency drives in schedule format
i) Temperature wells in schedule format
j) Room schedules
k) Refrigerant Monitor(s) in schedule format
l) Power and Water meter(s) in schedule format
m) Relays/Switches
n) Control Panels
o) 24 VAC power distribution panels
p) Power Supply
q) Batteries
r) Operator Interface Equipment
s) Software, licensing, and applications
t) Low-voltage Control, Power, and Communication wiring riser diagrams including nominal voltage ratings and bus speed

3) Wiring diagrams and layouts for each control panel. Show all termination numbers.
4) Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware.

c. Central System Hardware and Software:

1) A complete bill of material of equipment used, indicating quantity, manufacturer, model number, and other relevant technical data.
2) Manufacturer's description and technical data, such as product specification sheets and installation/maintenance instructions for the items listed below and other relevant items not listed below:

a) Laptop
b) Power Supply
c) Battery Backup
d) Interface Equipment Between CPU and Control Panels
e) Operating System Software
f) Operator Interface Software
g) Color Graphic Software
h) Third-Party Software and hardware

3) Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturer's model numbers and functions. Show all interface wiring to the control system.
4) Riser diagrams of wiring between central control unit and all control panels.
5) A list of the color graphic screens to be provided. For each screen, provide a conceptual layout of pictures and data and show or explain which other screens can be directly accessed.

d. Controlled Systems

1) Riser diagrams showing native and third party control network layout, communication protocol, proposed addressing, and wire types. The temperature controls contractor shall provide, install, and wire the required network equipment for all additional connections needed beyond the dedicated connections shown in the drawings. Approved addressing will be recorded and produced in final documentation deliverables.
2) A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
3) A schematic wiring diagram for each BAS. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the BAS schematic, it shall be labeled with the same name. All terminals shall be labeled.
4) An instrumentation list for each controlled system. Each element of the BAS shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

5) A control panel schematic layout indicating components mounted within or on each panel. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of each panel and appropriate panel labeling.
6) A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
7) A point list for each system controller including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device. Software flag points, alarm points, etc.
8) Include 24 VAC power trunk diagrams that illustrate wire routing, centralized panel locations, and equipment served by each circuit.
9) Interface with the exterior lighting third party controller.

e. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
f. A description of the proposed process along with all report formats and checklists to be used in Article 3.19, "Control System Demonstration and Acceptance."
g. Compliant with BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 with BTL certification and label for equipment provided under this scope of work. BACnet IP communication compliance with be native for ethernet level controllers.
h. Instrumentation and Data Point Summary Table. Contractor shall submit in table format with the following information for each instrument and data point. The table is to be reviewed and approved by the owner's representative prior to hardware and software installation and programming.

1) Point name
2) Point description: provide building designation, system type, equipment type, engineering units, and functionality; include a description of its physical location
3) Expected range (upper and lower limit)
4) Instrumentation (as applicable): manufacturer, model number, range, and accuracy specification
5) Type

a) AI: analog input
b) BI: binary input
c) NAI: network analog input
d) NBI: network binary input
e) CP: Configuration Property
f) P: Programmed (e.g., soft or virtual point in control sequence such as a PID input or output)
g) C: Calculated value; a soft or virtual point. If calculated value, provide logic diagrams or code and any constants used in formula. If time-based integrated values are required, provide time periods: minutes, daily, weekly, monthly, and yearly. Also indicate if it is a running average.

6) Input resolution

7) Graphic display resolution
8) Data trend interval indicating event-driven, COV, or polling method
9) Number of samples stored in local controller before transfer to host computer/server database
10) Data point address

2. Schedules:

a. Coordinate with General Contractor to provide work within the overall project schedule indicating the following:

1) Intended sequence of work items.
2) Start dates of individual work items.
3) Duration of individual work items.
4) Planned delivery dates for major material and equipment and expected lead times.
5) Milestones indicating possible restraints on work by other trades or situations.

c. Provide monthly written status reports indicating work completed, revisions to expected delivery dates, etc. An updated project schedule shall be included.

1.13 INFORMATIONAL SUBMITTALS

A. Project Record Documents: Upon completion of installation, submit three printed copies of record documents, along with electronic copies. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. As-built versions of the submittal shop drawings provided as files on flash drive or optical media and as 11" x 17" prints. Include final BMS communication routing with end of line resistor locations, 24 VAC power trunk diagrams, and network architecture information.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Article 3.19: "BAS Demonstration and Acceptance."
3. Certification of pressure test required in Article 3.10: "Control Air Tubing." 4. Operation and Maintenance (O & M) Manual.
5. As-built versions of submittal product data.
6. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
7. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
8. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
9. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

10. Documentation of all programs created using custom programming language including setpoints, tuning parameters, and object database.
11. Provide a copy of all electronic graphic files, programs, and database backups required to perform a restoration of original configuration for all controlled and monitored equipment.
12. List of recommended spare parts with part numbers and suppliers.
13. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
14. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
15. Licenses, guarantees, and warranty documents for equipment and systems.
16. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

B. Training Materials. Provide course outline and manual for each class at least six weeks before first class. The BAS designer will modify course outlines and manuals if necessary to meet Owner's needs. The BAS designer will review and approve course outlines and manuals at least three weeks before first class.

1.14 WARRANTY

A. Warrant work as follows:

1. Warrant labor and materials for specified BAS free from defects for a period of 12 months after final acceptance. BAS failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If the BAS designer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, The BAS designer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted.
   Demonstrate operable condition of reused devices at time of BAS designer's acceptance. B.

Special warranty on instrumentation:

1. All instrumentation shall be covered by manufacturer's transferable one-year "No Fault" warranty. If manufacturer warranty is not available, the BAS installer shall provide the same.

1.15 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

PART 2 - PRODUCTS

2.1 SECTION INCLUDES

A. Materials
B. Communication
C. Operator Interface
D. Controller Software
E. Building Controllers
F. Custom Application Controllers
G. Application-Specific Controllers
H. Input/Output Interface
I. Power supplies and Line Filtering
J. Auxiliary Control Devices
K. Wiring and Raceways

2.2 MATERIALS

A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this Work or the Owner and engineer shall be notified in writing as soon as the manufacturer announces end of life information.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet network. Controller and operator interface communication shall conform to BACnet ASHRAE Standard 195-2004 and SSPC-135 conformance and/or certification requirements. BACnet IP or MSTP communication shall be utilized and separate trunks provided to avoid the need to downgrade communication speeds due to third party devices.

B. Each controller shall have a communication port for connection to an operator interface.

C. Project drawings where indicated as remote buildings or sites to be connected by a fiber optic network that utilizes ethernet connectivity. In each remote location, the fiber optic network and field device ethernet connection shall allow communication with each controller on the internetwork as specified in Paragraph D.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to the BAS shall allow the operator to interface with each internetwork controller as if directly connected. BAS information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified BAS operation. An authorized operator shall be able to manage, maintain and access the BAS network of controllers.

E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring. Expansion shall not require operator interface hardware additions or software revisions.

F. Workstations, Building Control Panels and Controllers with real-time clocks shall use the open-protocol time synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable.

2.4 OPERATOR INTERFACE

A. Operator Interface. PC-based workstations shall reside on high-speed network with building controllers as shown on system drawings. Each workstation or each standard browser connected to server shall be able to access all BAS information.

B. Workstation and controllers shall communicate using BACnet protocol. Workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet communication addressing as specified in ASHRAE Standard 195-2004 and SSPC-135.

C. Hardware. Each operator workstation or web server shall consist of the following:

1. Laptop: Hardware shall meet or exceed BAS manufacturer's recommended specifications and shall meet response times specified elsewhere in this document. The following minimum hardware requirements also apply:

a. The hard drive shall have sufficient memory to store:

1) All required operator workstation software
2) A database at least twice the size of the delivered system database

3) One year of trend data based on the points specified to be trended at their specified trend intervals.

b. Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.

c. Minimum hardware configuration shall include the following: 1.8 GHz i7 CPU, 8 GB RAM, 512 GB solid state hard drive, and UHD 3840x2160 resolution display with 6.7M colors and 24-bit color depth.

d. The latest Windows Professional or server software fully licensed will be pre-installed via manufacturer image unless the Owner provides an image from which to build the environment.

e. All computer environments shall automatically cache and purge data as required to prevent total consumption of free hard drive space.

D. System Software

1. Operating System. Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications. Examples include Microsoft Excel, Microsoft Access or other SQL database software. Acceptable operating systems are Windows, the latest Windows Server release, Linux, and UNIX.

2. System Graphics. The operator workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.

3. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in industry standard formats such as PCX, TIFF, and GEM. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Designer or AutoCAD.

4. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

E. System Applications. Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation:

1. Automatic System Database Save and Restore. Each workstation shall store on the hard disk a copy of the current database of each Building Controller. This database shall be updated whenever a change is made in any system panel. The storage of these data shall be automatic and not require operator intervention. In the event of a database loss in a building management

panel, the first workstation to detect the loss shall automatically restore the database for that panel. This capability may be disabled by the operator.

2. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection.
4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application, editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time period shall be user-adjustable. All system security data shall be stored in an encrypted format.
6. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states, and reactions for each object in the system.
8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying upon acronyms or other mnemonics.
9. Alarm Reactions. The operator shall be able to determine (by object) what, if any, actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation, or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day.
10. Trend Logs. The operator shall be able to define a custom trend log for any data object in the system. This definition shall include interval, start time, and stop time. Trend data shall be sampled and stored on the building controller panel, be archived on the hard disk, and be retrievable for use in spreadsheets and standard database programs. Trend setpoints by change of value unless a reset schedule is used. Trending should use instantaneous values unless specified otherwise, but be configured appropriately for the application and use. Trend data shall be exportable in a standard electronic format (.xls, .csv, .xml) for analysis external to the BAS.
11. Alarm and Event Log. The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All alarms that have not been cleared by the operator shall be archived to the hard disk on the workstation. Provide a sufficient alarm description to identify location and associated system(s). 12. Group Trend Time Series Plots

    a. Provide user-selectable Y points.

b. Provide user-editable titles, point names, and Y axis titles.
c. Individual trended points shall be able to be grouped in groups of up to four points per plot with up to four plots per page.

13. X-Y Trend Plots

a. User-selectable X and Y trend inputs.
b. User-editable titles, point names, and X and Y axis titles.
c. User-selectable time period options:

1) a 1-day 24-hour period;
2) a 1-week 7-day period;
3) a 1-month period, with appropriate days for the month selected; or (4) a 1-year period.
4) The user shall be able to select the beginning and ending period for each X-Y chart, within the time domain of the database being used.

d. User-selectable display of up to 6 plots per screen in 2 columns.

14. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. The status shall be available by menu, on graphics, or through custom programs.
15. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archived on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of all objects by type or status (e.g., alarm, lockout, normal). Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing. Reports and logs shall be capable of being printed to the system printer, saved locally, or emailed.
16. Standard Reports. The following standard BAS system reports shall be provided for this project. Provide ability for the owner to readily customize these reports for this project.

a. All Objects/Points/Variables: All system (or subsystem) objects and their current values.
b. Alarm Summary: All current alarms (except those in alarm lockout).
c. Disabled Objects/points: All objects that are disabled.
d. Alarm Lockout Objects/points: All objects in alarm lockout (whether manual or automatic).
e. Alarm Lockout Objects/points in Alarm: All objects in alarm lockout that are currently in alarm.
f. Logs:

1) Alarm History
2) System Messages
3) System Events
4) Trends

17. Custom Reports. Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped and shall contain a report title and the name of the facility.
18. Tenant Override Reports. Provide a monthly report showing the daily total time in hours that each tenant has requested after-hours HVAC and lighting services. Provide an annual summary report that shows the override usage on a monthly basis.
19. Electrical, Gas, and Weather Reports

    a. Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each building meter.
    b. Provide an annual (12-month) summary report showing the monthly electrical consumption and peak demand with time and date stamp for each meter.
    c. Gas Meter Report: Provide a monthly report showing the daily natural gas consumption for each meter. Provide an annual (12-month) report that shows the monthly consumption for each meter.
    d. Weather Data Report: Provide a monthly report showing the daily minimum, maximum, and average outdoor air temperature, as well as the number of heating and cooling degree-days for each day. Provide an annual (12-month) report showing the minimum, maximum, and average outdoor air temperature for the month, as well as the number of heating and cooling degree-days for the month. If there is a weather station within 25 miles of the facility, provide real-time weather information via SOAP/XML. Otherwise, use weather values from the BAS.

20. Electrical, Gas, and Weather Graphic Display a. Provide a graphic display for each electrical meter and gas meter and weather data point(s) with a data table and a current 24-hour trend plot. Include data values for the following time periods; today, previous day, week to date, previous week, month to date, previous month, year to date, previous year.
21. ASHRAE Standard 147 Report: Provide a daily report that shows the operating condition of each chiller as recommended by ASHRAE Standard 147. At a minimum, this report shall include:

    a. Chilled water inlet and outlet temperature
    b. Chilled water flow
    c. Oil pressure and temperature
    d. Oil level
    e. Compressor refrigerant discharge temperature
    f. Compressor refrigerant suction temperature
    g. Addition of refrigerant
    h. Addition of oil
    i. Vibration levels or observation that vibration is not excessive
    j. Motor amperes per phase
    k. Motor volts per phase
    l. PPM refrigerant monitor level
    m. Ambient temperature (dry-bulb and wet-bulb)
    n. Date and time logged

F. Workstation Applications Editors. Each PC workstation shall support editing of all system applications. Provide editors for each application at the PC workstation. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and month. This shall consist of a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The start and stop times for each object shall be adjustable from this master schedule. Schedules shall be easy to copy to other objects and/or dates.
3. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The BAS shall be fully operable while custom routines are edited, compiled, and downloaded. The programming language shall have the following features:

    a. The language shall be English language oriented, be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and allow for free-form programming (i.e., not column-oriented or "fill in the blanks"). Alternatively, the programming language can be graphically based using function blocks as long as blocks are available that directly provide the functions listed below and that custom or compound function blocks can be created.
    b. A full-screen character editor/programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete custom programming code. It also shall incorporate word processing features such as cut/ paste and find/replace. The debugger also shall provide error messages for syntax and execution errors.
    c. The programming language shall support conditional statements (IF/THEN/ELSE/ ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
    d. The programming language shall support floating-point arithmetic using the following operators: +, -, /, ×, and square root. The following mathematical functions also shall be provided: absolute value and minimum/ maximum value from a list of values.
    e. The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval-timing functions can be stopped and started within a program. Values from all of the above variables shall be readable by the language so that they can be used in a program for such purposes as IF/THEN comparisons, calculations, etc.
    f. The language shall be able to read the values of the variables and use them in programming statement logic, comparisons, and calculations.
    g. The programming language shall have predefined variables representing the status and results of the System Software and shall be able to enable, disable, and change the set points of the System Software described below.
    h. The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.

i. The editor/programming environment shall have a debugging/simulation capability that allows the user to step through the program and observe any intermediate values and/or results. The debugger also shall provide error messages for syntax and execution errors.

2.5 CONTROLLER FIRMWARE

A. Furnish the following applications software for building and energy management. All software applications shall reside and operate in the system controllers. Editing of applications shall occur at the operator workstation.

B. System Security

1. User access shall be secured using individual security passwords and user names.
2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager. At least six levels of user rights shall be configured by the temperature controls contractor for no view up to full privileges.
3. User Log On/Log Off attempts shall be recorded.
4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

C. System Coordination. Provide a standard application for the proper coordination of equipment. This application shall provide the operator with a method of grouping together equipment based on function and location. This group may then be used for scheduling and other applications.

D. Scheduling. Provide the capability to schedule each object or group of objects in the BAS. Each schedule shall consist of the following:

1. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. Each schedule may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to adjust the start and stop times for each member.
2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
3. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
4. Before project close-out, the contractor shall create schedules for each piece of equipment (not just provide the capability to do so).

E. Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

F. Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.

G. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the appropriate workstations based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics. The system shall be capable of individual user rights to prevent unauthorized personnel from manipulating an alarm.

H. Remote Communication. The system shall have the ability to transmit the alarm/event using the BACnet communication protocol control network. The alarms shall be capable of delivery via email, pager, text message, and local display. I. Demand Limiting.

1. The demand-limiting program shall monitor building power consumption from signals generated by a pulse generator (if provided by electrical contractor) mounted at the building power meter or from a watt transducer or current transformer attached to the building feeder lines.
2. The demand-limiting program shall predict the probable power demand such that action can be taken to prevent exceeding the demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates the demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Demand reduction shall be accomplished by the following means:

    a. Reset air-handling unit supply temperature set point up by 1ºC (2ºF).
    b. Reset space temperature set points up by 1ºC (2ºF).
    c. De-energize equipment based upon priority.

4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which the local power company computes demand charges.
5. Provide demand-limiting prediction and control for any individual meter monitored by the system or for the total of any combination of meters.
6. Provide the means for an operator to make the following changes on-line:

    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/restore priority.

7. Provide the following information and reports, to be available on an hourly, daily, and monthly basis:

    a. Total electric consumption.
    b. Peak demand.
    c. Date and time of peak demand.
    d. Daily peak demand.

J. Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits.

K. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence chillers, boilers, and pumps.

L. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and PID gains shall be user-selectable.

M. Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user-selectable. N. Energy Calculations.

1. Provide software to allow instantaneous power (e.g., kW) or flow rates (e.g., L/s (gpm)) to be accumulated and converted to energy usage data.
2. Provide an algorithm that calculates a sliding-window average (e.g., rolling average). The algorithm shall be flexible to allow window intervals to be user specified (e.g., 15 minutes, 30 minutes, 60 minutes).
3. Provide an algorithm that calculates a fixed-window average. A digital input signal will define the start of the window period (e.g., signal from utility meter) to synchronize the fixed-window average with that used by the utility.

O. Anti-Short Cycling. All binary output objects shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

P. On/Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and set point. The algorithm shall be direct-acting or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization. Provide software to totalize run-times for all binary input objects. A high run-time alarm shall be assigned, if required, by the operator.

2.6 BUILDING CONTROLLERS

A. General. Provide an adequate number of building controllers to achieve the performance specified in the Article 1.9, "BAS Performance." Each of these panels shall meet the following requirements.

1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor-based building controllers to manage the global strategies described in the System Software section.
2. The building controller shall have sufficient memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked building controllers.

4. The operating system of the building controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. The building controller shall continually check the status of its communication, processor, and memory circuits. If an abnormal operation is detected, the controller shall assume a predetermined failure mode and generate an alarm notification.
7. The Building Controller shall communicate with networked BAS devices on the network using the protocol-specific communication requirements. Controller-to-controller communication shall be peer-to-peer and not require a master or host server for communication.
8. The Building Controller shall be certified, listed by or submitted for testing to a testing laboratory approved by BACnet ASHRAE Standard 195-2004 and SSPC-135 communication. B. Communication.

1. Each building controller shall reside on the BACnet network.
2. The controller shall provide a communication port connection or network interface for a portable operator's terminal.
3. Network routers/repeaters/bridges shall be used to extend communications, change media type, or extend the network in order to ensure proper communication for the entire BAS. Only one connection to the owner's LAN shall be allowed for building level controllers and it is the responsibility of this contractor to provide network equipment for connection of additional equipment.

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at -40°C to 65°C (-40°F to 150°F).
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

D. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

E. Memory. The building controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2.7 CUSTOM APPLICATION CONTROLLERS

A. General. Provide an adequate number of Custom Application Controllers to achieve the performance specified in the Article1.9 on "BAS Performance." Each of these panels shall meet the following requirements.

1. The custom application controller shall have sufficient memory to support its operating system, database, and programming requirements.
2. Data shall be shared between networked custom application controllers.
3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms.
4. Controllers that perform scheduling shall have a real-time clock.
5. The custom application controller shall continually check the status of its communication, processor and memory circuits. If an abnormal operation is detected, the controller shall:

    a. assume a predetermined failure mode and
    b. generate an alarm notification.

6. The custom application controller shall communicate with other open-protocol devices on the network using the protocol specific services.
7. All network controllers shall be tested and certified or listed by an official open-protocol testing laboratory as being compliant with the standardized open-protocol device capabilities.

B. Communication.

1. Each custom application controller shall reside on a control network using the device-level protocol.
2. The controller shall provide a service communication port or network interface using an open-protocol for connection to a portable operator's terminal.

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at -40°C to 65°C (-40°F to 150°F).
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

D. Touch Display. A local LCD touch display shall be provided where indicated on the drawings or required by the sequence of operation. The display shall be provided for interrogating and editing specified building automation data. An optional system security password shall be available to prevent unauthorized use of the display. The portable operator terminal described in section 2.4.G is not a suitable substitute for mounted fixed position display requirements.

E. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

F. Memory. The custom application controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

G. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

H. Spare Controllers: Two (2) spare controllers for each unique controller provided.

2.8 APPLICATION SPECIFIC CONTROLLERS

A. General. Application specific controllers (ASCs) are microprocessor-based BAS controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user-programmable but are customized for operation within the confines of the equipment they are designed to serve. ASCs shall communicate with other BAS open-protocol on the devices on the network using the open-protocol-specific read (execute) property service.

1. Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
2. Each ASC will contain sufficient I/O capacity to control the target system.
3. Each ASC shall be certified or listed for compliance to the BACnet ASHRAE standard 195-2004 and SSPC-135 standards.

B. Communication.

1. The controller shall reside on the open-protocol network using RS-485 MSTP Physical media. Each network of controllers shall be connected to one building controller.
2. Each controller shall have an BACnet communication compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port where shown.

C. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at -40°C to 65°C (-40°F to 150°F).
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

D. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

E. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.

F. Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

G. Transformer. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

H. Spare Controllers: Two (2) spare controllers for each unique controller provided.

2.9 INPUT/OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the BAS through building, custom application, or application specific controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.

D. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

E. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with-and field configurable to-commonly available sensing devices.

F. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override where indicated on the drawings or required by the sequence of operation. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

I. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

J. Input/Output points shall be the universal type, i.e., controller input or output may be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.

K. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for

this project shall not require any hardware additions or software revisions in order to expand the system.

2.10 POWER SUPPLIES AND LINE FILTERING

A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.

a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.
b. Line voltage units shall be UL recognized and CSA approved.

2. Unless specified otherwise, 24 VAC power requirements for terminal unit controllers shall be provided by this contractor using daisy chained power of 100, 200, 300, or 500 VA power sources appropriately loaded with consideration for voltage drop. Each power supply output shall offer isolated, 24 VAC, Class 2 outputs. The power supply shall be protected and have provisions to prevent overheating. B. Power line filtering.

1. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:

a. Dielectric strength of 1000 volts minimum
b. Response time of 10 nanoseconds or less
c. Transverse mode noise attenuation of 65 dB or greater
d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz

2.11 AUXILIARY CONTROL DEVICES

A. Motorized control dampers, unless otherwise specified elsewhere, shall be as follows:

1. Control dampers shall be the parallel or opposed blade type as below or as scheduled on drawings.

a. Outdoor and/or return air mixing dampers and face and bypass (F&BP) dampers shall be parallel blade, arranged to direct air streams toward each other.
b. Other modulating dampers shall be the opposed blade type.
c. Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.

2. Damper frames shall be 13 gauge galvanized steel channel or 1/8 in. extruded aluminum with reinforced corner bracing.

3. Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades are to be suitable for medium velocity performance (10 m/s (2000 fpm)). Blades shall be not less than 16 gauge.
4. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze or better.
5. All blade edges and top and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel. The blade seals shall provide for a maximum leakage rate of 50 L/s·m2 (10 cfm per ft2) at 1000 Pa (4 in. w.g.) differential pressure. Provide air foil blades suitable for a wide-open face velocity of 7.5 m/s (1500 fpm).
6. Individual damper sections shall not be larger than 125 cm × 150 cm (48 in. × 60 in.). Provide a minimum of one damper actuator per section.
7. Modulating dampers shall provide a linear flow characteristic where possible.
8. Dampers shall have exposed linkages.
9. TAMCO 1500 series or TAMCO 9000 series for outside air applications, Ruskin CD50 or CD50TI for outside air applications, or approved equal. B. Electric damper/valve actuators.

1. The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.
2. For outside air applications and where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing. Alternatively, an Uninterruptible power supply (UPS) may be provided.
3. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range.
4. All 24 VAC/VDC actuators shall operate on Class 2 wiring
5. All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank for this purpose. Acceptable Manufacturers: Belimo, Schneider Electric, or approved equal. C. Pneumatic damper/valve actuators and positioners.

1. Pneumatic actuators shall be piston-rolling diaphragm type or diaphragm type with easily replaceable, beaded, molded neoprene diaphragm.
2. Actuator housings may be molded or die-cast zinc or aluminum. Exception: Actuator housings for terminal unit zone control dampers or valves may be of high-impact plastic construction with an ambient temperature rating of 10°C to 60°C (50°F to 140°F) minimum. However, any plastic devices located in return air (ceiling) plenums shall be isolated from plenums with an auxiliary metal enclosure having a quick-opening access panel.
3. Actuator size and spring ranges selected shall be suitable for intended application.
4. Rate pneumatic actuators for a minimum 140 kPa (20 psig).
5. Damper actuators shall be selected in accordance with manufacturer's recommendations to provide sufficient close-off force to effectively seal damper and to provide smooth modulating control under design flow and pressure conditions. Furnish a separate actuator for each damper section.
6. Valve actuators shall provide tight close-off at design system pressure and shall provide smooth modulation at design flow and pressure conditions.

7. On sequencing applications, valve and damper actuators shall be sized for a maximum of 14 kPa (2 psi) shift in nominal spring range. Spring ranges shall be selected to prevent overlap or positive positioners shall be provided.
8. Positive positioners to have the following performance characteristics:

    a. Linearity: ±10% of output signal span
    b. Hysteresis: 3% of the span
    c. Response: 1/4 psig input change
    d. Maximum pilot signal pressure: 140 kPa (20 psig)
    e. Maximum control air supply pressure: 420 kPa (60 psig)

9. Positive positioners shall be provided on actuators for inlet vane control and on any other actuators where required to provide smooth modulation or proper sequencing.
10. Positive positioners shall be high-capacity force balance relay type with suitable mounting provisions and position feedback linkage tailored for particular actuator.
11. Positive positioners shall use full control air pressure at any point in stem travel to initiate stem movement or to maintain stem position. Positioners shall operate on a 20 to 100 kPa (3 to 15 psig) input signal unless otherwise required to satisfy the control sequences of operation. D. Control valves.

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown in the drawings. Acceptable Manufacturers: Belimo, Schneider Electric, or approved equal.
2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

    a. Water Valves:

        1) Two-way: 150% of total system (pump) head.
        2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

    b. Steam Valves: 150% of operating (inlet) pressure.

3. Water Valves:

    a. Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
    b. Sizing Criteria:

        1) Two-position service: Line size.
        2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
        3) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.

4) Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
5) Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

c. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

1) Water zone valves-normally open preferred.
2) Heating coils in air handlers-normally open.
3) Chilled water control valves-normally closed.
4) Other applications-as scheduled or as required by sequences of operation.

E. Binary Temperature Devices

1. Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) set point range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
2. Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
3. Low-limit thermostats. Low-limit air stream thermostats shall be UL listed, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by any 30 cm (1 ft) section. Provide the appropriate number of thermostats to provide adequate coverage per the manufacturer recommendation. Install on the discharge side of the first heating water coil one or more low-limit thermostat(s) to protect the water coils in all air streams subject to unconditioned outside air whether indicated in the drawings or not. Provide hardwired interlock interruption of equipment operation and a separate hardwired BAS signal for monitoring and alarm. Provide DPDT snap acting 16A@120VAC rated contacts set for 38F or above. The low-limit thermostat shall be manual reset only. Approved Manufacturer: Johnson A70 or approved equal.

F. Temperature sensors.

1. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
2. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m2 (10 ft2) of duct cross section. Discharge sensors shall have programming to minimize stratification in equipment discharge temperature by limiting discharge to 90F. Any application with discharge temperature shall also take corrective action to prevent coil freeze conditions if outside air is introduced in the air stream.
3. Immersion sensors shall be provided with a separable stainless steel well and thermal compound. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.
4. Space sensors shall be equipped with set point adjustment, override button, display, and communication port unless specified otherwise in the drawing. Provide a stainless steel flat plate with tamper proof screws in areas subject to vandalism or damage.
5. Provide matched temperature sensors for differential temperature measurement.

6. Provide NEMA 3R sealed sensor with sealtite fittings, stainless steel bushings, and solar shield for outside air temperature and humidity sensing. Locate on North side of building out of direct sunlight if not specified otherwise.
7. Line voltage thermostats shall be provided where indicated in the drawings and be provided with concealed adjustment and common keyed lockable guard. G. Humidity sensors.

1. Duct and room sensors shall have a sensing range of 20% to 80%.
2. Duct sensors shall be provided with a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall be suitable for ambient conditions of -40°C to 75°C (-40°F to 170°F).
4. Humidity sensor's drift shall not exceed 1% of full scale per year.
5. If sensing devices are not field replaceable, provide calibration kit. H. Flow switches.

1. Flow-proving switches shall be either paddle or differential pressure type, as shown.
2. Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum) and shall have adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.
3. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.

I. Relays.

1. Control relays shall be UL listed and enclosed for applications outside of a control panel or din rail mounted within a control panel. Provide an "energized" indicator for din rail mounted relay applications were the sequence requires local feedback. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.
3. For lighting applications provide contacts rated appropriate for the application with split low-voltage coils. State shall be retained after power failure.

J. Override timers.

1. Override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.

K. Current transmitters.

1. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges

shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and ±1% full-scale accuracy at 500 ohm maximum burden.

2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring or fixed core type for new applications. Wrap wiring per manufacturer recommendations and as required for proper sensing.

L. Current transformers.

1. AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively. Wrap wiring per manufacturer recommendations and as required for proper sensing.

M. Voltage transmitters.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.
2. Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ±1% full-scale accuracy with 500 ohm maximum burden.
3. Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

N. Voltage transformers.

1. AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated, complete with built-in fuse protection **and manual reset breakers.**
2. Transformers shall be suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and shall provide ±0.5% accuracy at 24 VAC and a 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic material.
4. For VAV applications, provide PSH 300A or 500A or approved equal as appropriate to power multiple controllers from a centralized source. Locate per drawings and coordinate with division 26 contractor for electrical room installation if not indicated otherwise.

O. Power and Phase Monitors

1. Selectable rate pulse output for kWh reading, 4-20 mA output for kW reading, N.O. alarm contact, and ability to operate with 5.0 amp current inputs or 0-0.33 volt inputs.
2. 1.0% full-scale true RMS power accuracy, + 0.5 Hz, voltage input range 120-600 V, and auto range select.
3. Under voltage/phase monitor circuitry.
4. NEMA 1 enclosure.
5. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0-0.33 V output. If 0-5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is

required. BACnet IP or MSTP communication of points to building automation system included. Acceptable Manufacturer using appropriate series: Eaton Electrical, Siemens, Square-D, or approved equal.

P. Hydronic Flow Meters - Acceptable Manufacturer: Onicon or Badger

1. Insertion-Type Turbine Meter

a. Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
b. Insertion type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
c. Sensing method shall be impedance sensing (nonmagnetic and non-photoelectric)
d. Volumetric accuracy

1) ± 0.5% of reading at calibrated velocity
2) ± 1% of reading from 3 to 30 ft/s (10:1 range)
3) ± 2% of reading from 0.4 to 20 ft/s (50:1 range)

e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% and traceable to the U.S. National Institute Standards and Technology (NIST).
f. Maximum operating pressure of 400 psi and maximum operating temperature of 200*F continuous (220*F peak).
g. All wetted metal parts shall be constructed of 316 stainless steel.
h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 V, and current output of 4-20 mA.

2. Magnetic Flow-Tube Type Flow Meter - Line size inline electromagnetic flow meter required for all hot and chilled water applications above 2". Acceptable Manufacturer: Onicon FT-3000 series, Badger Recordall Compound series, or approved equal.

b. Sensor shall be a magnetic flow meter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of 2 elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
c. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
d. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.
e. Flow Tube:

1) ANSI class 150 psig steel

2) ANSI flanges
3) Protected with PTFE, PFA, or ETFE liner rated for 245ºF minimum fluid temperature

f. Electrode and grounding material

1) 316L Stainless steel or Hastelloy C
2) Electrodes shall be fused to ceramic liner and not require O-rings.

g. Electrical Enclosure: NEMA 4, 7
h. Approvals:

1) UL or CSA.
2) NSF Drinking Water approval for domestic water applications

i. Performance

1) Accuracy shall be ±0.5% of actual reading from 3 to 30 feet per second flow velocities, and 0.015 fps from 0.04 fps to 3 fps.
2) Stability: 0.1% of rate over six months.
3) Meter repeatability shall be ± 0.1% of rate at velocities > 3 feet per second.

3. Magnetic Insertion-Type Flow Meters

a. Magnetic Faraday point velocity measuring device.
b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: larger of 1% of reading and 0.2 fps.
e. Flow range: 0.2 to 20 fps, bidirectional.
f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% and traceable to the U.S. National Institute Standards and Technology (NIST).

4. Vortex Shedding Flow Meter
a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
b. Maximum Fluid Temperature: 800ºF (427 □C).
c. Wetted Parts: Stainless Steel.
d. Housing: NEMA 4X.
e. Turndown: 25:1 minimum.
f. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
g. Body: Wafer style or ANSI flanged to match piping specification.

5. Transit Time Ultrasonic Flow Meter

a. Clamp-On transit-time ultrasonic flow meter

b. Wide-Beam transducer technology
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: 0.5% of reading in range 1 to 30 fps, 0.001 fps sensitivity.

Q. Thermal Energy Meters

1. Matched RTD or thermistor temperature sensors with a differential temperature accuracy of ±0.15°F.
2. Flow meter that is accurate within ±1% at calibrated typical flow rate and does not exceed ±2% of actual reading over an extended 50:1 turndown range.
3. Unit accuracy of ±1% factory calibrated, traceable to NIST with certification.
4. NEMA 1 enclosure.
5. Panel mounted display.
6. UL listed.
7. Isolated 4-20 ma signals for energy rate and supply and return temperatures and flow. Energy meter shall be equipped with an instantaneous flow and a totalized flow with a totalizer that can hold one month of data

R. Current switches.

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

S. Pressure transducers.

1. Transducer shall have linear output signal. Zero and span shall be field adjustable.
2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
3. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.
4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.
5. Pressure transmitter shall be mounted in a NEMA 1 bypass five-valve assembly panel . A complete maintenance solution including but not limited to: Air bleed, bypass valves, and compression fittings shall be provided with the assembly panel.

T. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown. For safety applications, manual reset shall be required.

U. Pressure-Electric (PE) Switches.

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-25 psig, with calibrated scale setpoint range of 2-18 psig minimum, UL listed.
2. Provide one- or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
3. Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
4. Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.

W. Local control panels.

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
2. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

X. Carbon Dioxide sensors.

1. Self-calibrating measurements of carbon dioxide concentration levels of 0 to 2,000 PPM ±40 PPM or 3% at 25°C accuracy.
2. Measurement type shall be non-dispersive Infrared (NDIR).
3. Sensor output shall be 4-20 mA or 0-10 VDC (field selectable) Reverse voltage protected and output limited.
4. Sensor power shall be either 24 VAC or VDC.
5. Return duct mounted for large spaces where one air handler serves a single zone. IP64-NEMA 3R required.
6. Wiring connections shall be screw terminal block (14 to 22 AWG).
7. Relay outputs with contact ratings of 2A at 30 VDC.
8. Provide calibration kit if not field replaceable sensing devices.
9. Acceptable Manufacturer: Veris, Dwyer, or Amphenol Advanced Sensors T8000 series for space sensing and Telaire 7001 for outside air CO2 sensing.

2.12 WIRING AND RACEWAYS

A. General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 26.

B. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.

2.13 MISCELLANEOUS DEVICES

A. Variable Frequency Motor Controllers.

1. Variable frequency drives for control of all HVAC equipment shall be provided by the BMS contractor unless specified otherwise. See specification section 232923 for requirements. Unless specified otherwise, the division 26 contractor shall mount and wire incoming and outgoing wiring.

B. Control Panels.

1. All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts. All control panels shall utilize UL listed components and where indicated on the drawings, be UL inspected, and listed as an assembly. Where required by building code, control panels will carry a UL 508 label listing compliance. Control panels shall be fully enclosed with perforated sub-panel, hinged door, and slotted flush latch. Ventilation slots shall be installed where required.
2. Provide DIN rail mounted terminal blocks and fuses where appropriate for all external connections.
3. Low and line voltage wiring shall be segregated. All provided terminal blocks and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring and bends.
4. All wiring shall be neatly installed and concealed in plastic wire run trays.
5. All 120 VAC power branch feeds from distribution panels to the temperature control and VAV power distribution panels shall be by the division 26 contractor unless specified otherwise.

PART 3 - EXECUTION

3.1 SECTION INCLUDES

A. Examination
B. Protection
C. Coordination
D. General Workmanship
E. Field Quality Control
F. Existing Equipment
G. Wiring
H. Communication Wiring
I. Control Air Tubing
J. Installation of Sensors
K. Flow Switch Installation
L. Actuators
M. Identification of Hardware and Wiring
N. Controllers
O. Programming
P. BAS Checkout and Testing
Q. BAS Demonstration and Acceptance
R. Cleaning

S. Training
T. Sequences of Operation

3.2 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/BAS designer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the BAS designer for resolution before rough-in work is started.

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate-or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others-the contractor shall report these discrepancies to the BAS designer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by-and at the expense of-this contractor. All request for information shall be communicated through and include the appropriate trades for comprehensive awareness.

3.3 PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.4 COORDINATION

A. Site

1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
2. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Submittals. Refer to Article 1.10, "Submittals" of this specification for requirements.

C. Test and Balance

1. The contractor shall furnish a single set of all tools necessary to interface to the BAS for test and balance purposes.
2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Life Safety

1. Duct smoke detectors required for air handler shutdown are supplied under Division 26 of this specification. The contractor shall interlock smoke detectors to air handlers for shutdown as described in Part 3, "Sequences of Operation."
2. Smoke dampers and actuators required for duct smoke isolation are provided under a Section of Division 23. The contractor shall interlock these dampers to the air handlers as described in Article, "Sequences of Operation," in this Section.
3. Fire/smoke dampers and actuators required for fire rated walls are provided under another Section of Division 23. Control of these dampers shall be by Division 26. The contractor shall provide control air to the dampers.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the BAS specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1. All communication media and equipment shall be provided as specified in "Communication" Article of this specification.
2. Each supplier of a controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
3. The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.5 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.6 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall help coordinate to have work inspected by local and/ or state authorities having jurisdiction over the work.

3.7 EXISTING EQUIPMENT

A. Wiring: The contractor may reuse any abandoned wires. The integrity of the wire and its proper application to the installation are the responsibility of the contractor. The wire shall be properly identified and tested in accordance with this specification. Unused or redundant wiring must be properly identified as such.

B. Local Control Panels: The contractor may reuse any existing local control panel that does not have a plastic cover to locate new equipment. All redundant equipment within these panels must be removed. Panel face cover must be patched to fill all holes caused by removal of unused equipment or replaced with new.

C. Unless otherwise directed, the contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the BAS Designer is to be notified immediately.

D. Temperature Sensor Wells: The contractor may reuse any existing wells in piping for temperature sensors. These wells shall be modified as required for proper fit of new sensors.

E. Indicator Gauges: Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy. Maintain the operation of existing pneumatic transmitters and gauges.

F. Electronic Sensors and Transmitters: Unless specifically noted otherwise, remove and offer first right of refusal to the owner.

G. Controllers and Auxiliary Electronic Devices: Unless specifically noted otherwise, remove and deliver to the Owner or become the property of the contractor if not retained.

H. Damper Actuators, Linkages, and Appurtenances: Unless specifically noted otherwise, remove and deliver to the Owner or become the property of the contractor if not retained.

I. Control Valves: Replace with new.

J. The mechanical system must remain in operation between the hours of 6 a.m. and 6 p.m., Monday through Friday. No modifications to the system shall cause the mechanical system to be shut down for more than 15 minutes or to fail to maintain space comfort conditions during any such period. Perform cut-over of controls that cannot meet these conditions outside of those hours.

K. The scheduling of fans through existing or temporary time clocks or BAS shall be maintained throughout the BAS installation.

L. Install control panels where shown.

M. Modify existing starter control circuits, if necessary, to provide hand/off/auto control of each starter controlled. If new starters or starter control packages are required, these shall be included as part of this contract.

N. Patch holes and finish to match existing walls.

3.8 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes and Division 26 of this specification. Where the requirements of this section differ from those in Division 26, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 26 requirements.

C. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.)

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL Listed for the intended application. For example, cables used in ceiling plenums shall be UL Listed specifically for that purpose.

E. All wiring in mechanical, electrical, or service rooms-or where subject to mechanical damage- shall be installed in raceway at levels below 3 m (10 ft).

F. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

G. Do not install wiring in raceway containing tubing.

H. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.

I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

L. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

O. Size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

P. Include one pull string in each raceway 2.5 cm (1 in.) or larger.

Q. Use coded conductors throughout with conductors of different colors.

R. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

S. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).

T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

U. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.

V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

W. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

X. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

Y. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.9 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" Article of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

C. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring. Do not install communication wiring with bundles of other wire type that allow for parallel runs with medium or high voltage present.

D. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available. Appropriate manufacturer recommended shielded low-capacitance cabling shall be utilized.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

J. Provide more than one communication port on ethernet level controllers to segregate third party communication and maximize bus speed.

K. Spot locations for end of line resistors and indicate if built-into controller or externally biased.

3.11 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing and be insulated if located on an outside wall or subject to outside air.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m2 (1 ft of sensing element for each 1 ft2) of coil area.

G. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

I. Differential air static pressure.

1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
2. Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
3. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

3.12 FLOW SWITCH INSTALLATION

A. Adjust flow switch in accordance with manufacturer's instructions.

3.13 ACTUATORS

A. Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic

1. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.14 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 5 cm (2 in.) of termination with the BAS address or termination number.

B. All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

C. Permanently label or code each point of field terminal strips to show the instrument or item served.

D. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

E. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

F. Identify room sensors relating to terminal box or valves with nameplates.

G. Manufacturer's nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

H. Identifiers shall match record documents.

3.15 CONTROLLERS

A. Provide a separate controller for each AHU or other HVAC system. A BAS controller may control more than one system provided that all points associated with the system are assigned to the same BAS

controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement. Do not provide multiple separate controllers that rely upon communication to control a single HVAC system. Provide all required node and controller permanent licensing.

B. Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 20% of each type is required. If outputs are not universal, 20% of each type is required. A minimum of one spare is required for each type of point used.

1. Future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software. No additional controller boards or point modules shall be required to implement use of these spare points.

3.16 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Use the existing standard or follow the naming convention: AA.BBB.CCDDE where:

1. AA is used to designate the location of the point within the building, such as mechanical room, wing, or level, or the building itself in a multi-building environment,
2. BBB is used to designate the mechanical system with which the point is associated (e.g., A01, HTG, CLG, LTG),
3. CC represents the equipment or material referenced (e.g., SF for supply fan, RW for return water, EA for exhaust air, ZN for zone),
4. D or DD may be used for clarification or for identification if more than one CC exists (e.g., SF10, ZNB),
5. E represents the action or state of the equipment or medium (e.g., T for temperature, H for humidity, C for control, S for status, D for damper control, I for current).

C. Software Programming

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

a. Text-based:

1) Must provide actions for all possible situations
2) Must be modular and structured 3) Must be commented

b. Graphic-based:

1) Must provide actions for all possible situations 2) Must be documented

c. Parameter-based:

1) Must provide actions for all possible situations
2) Must be documented

D. Operator Interface

1. Standard graphics-Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points. Non-subscription based permanent licensing shall allow for more than one concurrent operator.
2. Show terminal equipment information on a "graphic" summary table. Provide dynamic information for each point shown.
3. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.17 BAS SYSTEM CHECKOUT AND TESTING

A. Start-up Testing: All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating BAS. This testing shall be completed before the owner's representative is notified of the system demonstration.

1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines. Coordinate with manufacturer for all points Integrated BACnet points to link appropriate points to applicable graphics. Report any discrepancies to the Architect.
7. Alarms and Interlocks:

a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.18 BAS DEMONSTRATION AND ACCEPTANCE

A. Demonstration

1. Prior to acceptance, the BAS shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in Article 3.18 "BAS System Checkout and Testing" of this specification. The BAS designer will be present to observe and review these tests. The BAS designer shall be notified at least 10 days in advance of the start of the testing procedures.
3. The demonstration process shall follow that approved in Article 1.10, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1, "BAS Performance."
7. Demonstrate compliance with sequences of operation through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:

a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be in compliance with Table 1 point requirements. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of shedding equipment outputs.

c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

d. Interface to the building fire alarm system.

e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/BAS designer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the BAS designer and owner prior to the acceptance of the BAS as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the BAS designer. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Article 1.10, "Submittals."

3.19 CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.20 TRAINING

A. Provide a minimum of two on-site or classroom training sessions, two hours each, throughout the contract period for personnel designated by the owner.

B. Provide two additional training sessions at 6 and 12 months following building's turnover. Each session shall be two hours in length and must be coordinated with the building owner.

C. Train the designated staff of owner's representative and owner to enable them to do the following:

1. Day-to-day Operators:

    a. Proficiently operate the system
    b. Understand BAS architecture and configuration
    c. Understand DDC system components
    d. Understand system operation, including BAS control and optimizing routines (algorithms)
    e. Operate the workstation and peripherals
    f. Log on and off the system
    g. Access graphics, point reports, and logs
    h. Adjust and change system set points, time schedules, and holiday schedules
    i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
    j. Understand system drawings and Operation and Maintenance manual
    k. Understand the job layout and location of control components
    l. Access data from DDC controllers and ASCs
    m. Operate portable operator's terminals

2. Advanced Operators:

    a. Make and change graphics on the workstation
    b. Create, delete, and modify alarms, including annunciation and routing of these
    c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
    d. Create, delete, and modify reports
    e. Add, remove, and modify system's physical points
    f. Create, modify, and delete programming
    g. Add panels when required
    h. Add operator interface stations
    i. Create, delete, and modify system displays, both graphical and others
    j. Perform BAS field checkout procedures
    k. Perform BAS unit operation and maintenance procedures
    l. Perform workstation and peripheral operation and maintenance procedures
    m. Perform BAS diagnostic procedures
    n. Configure hardware including PC boards, switches, communication, and I/O points
    o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
    p. Adjust, calibrate, and replace system components

3. System Managers/Administrators:

    a. Maintain software and prepare backups
    b. Interface with job-specific, third-party operator software
    c. Add new users and understand password security procedures

D. These objectives will be divided into three logical groupings. Participants may attend one or more of these, depending on level of knowledge required.

1. Day-to-day Operators: parts 1-13
2. Advanced Operators: parts 1-29
3. System Managers/Administrators: parts 1-13 and 30-32

E. Provide course outline and materials in accordance with Article 1.10 "Submittals" of this specification. The instructor(s) shall provide one copy of training material per student.

F. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

G. Classroom training shall be done using a network of working controllers representative of the installed hardware.

3.21 SEQUENCES OF OPERATION

A. Provide operation as shown on drawings.

B. Whether shown in the drawings or not, the following programming considerations will be provided for all solutions:
1. Anti-short cycle timers shall prevent outputs from cycling faster than appropriate for the equipment being controlled to prevent potential damage.
2. All freeze, fire, or life safety conditions sensed, regardless of sensor type, shall result in equipment shutdown and protection unless specified otherwise. Hardwire local devices and safety circuits to eliminate reliance upon communication for equipment protection.
3. Consolidate equipment to minimize communication requirements by utilizing appropriately sized controllers to accommodate nearby systems and future needs.

3.22 CONTROL VALVE INSTALLATION

A. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.

B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.

C. Valves shall be installed in accordance with the manufacturer's recommendations.

D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.

E. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.

F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.23 CONTROL DAMPER INSTALLATION

A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.

B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.

C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8 in.) of each other.

D. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.

E. Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

G. Provide a visible and accessible indication of damper position on the drive shaft end.

H. Support ductwork in area of damper when required to prevent sagging due to damper weight.

I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.25 DUCT SMOKE DETECTION

A. Submit data for coordination of duct smoke detector interface to HVAC systems as required in Action Submittals.

B. This Contractor shall hard wire interface the dry-contact alarm output(s) for the HVAC equipment to be controlled and interlock equipment shutdown as appropriate.

3.26 CONTROLS COMMUNICATION PROTOCOL

A. General. The electronic controls packaged with this equipment shall communicate with the building BAS. The BAS shall communicate with these controls to read the information and change the control set points as shown in the points list, sequences of operation, and control schematics. The information to be communicated between the BAS and these controls shall be in the standard object format as defined in the open protocol. Controllers shall communicate with other open protocol objects on the network using. the protocol-specific service as defined by the protocol selected. The control system provided shall be based on BACnet MS/TP architecture and adhere to BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9. The supervisory controller and all connected controllers shall be BACnet Testing Labs (BTL) certified and carry a BTL label.

B. Distributed Processing. The controller shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

C. I/O Capacity. The controller shall contain sufficient I/ O capacity to control the target system.

D. Communication. The controller shall reside on a BAS open protocol network using the device level protocol. Each network of controllers shall be connected to one building controller.

E. The Controller shall have a network connection for a laptop computer or a portable operator's tool.

F. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at □40°C to 65°C (□40°F to 150°F).
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

G. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

H. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 90 days.

I. Immunity to Power and Noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

J. Transformer. Power supply for the Controller must be rated at minimum of 125% of ASC power consumption and shall be fused or current limiting type.

3.27 START-UP AND CHECKOUT PROCEDURES

A. Start up, check out, and test all hardware and software and verify communication between all components.

1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
2. Verify that all analog and binary input/output points read properly.
3. Verify alarms and interlocks.
4. Verify operation of the integrated system.

END OF SECTION 230900

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. Pressure regulators.

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. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Pressure regulators. Indicate pressure ratings and capacities.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For motorized gas valves and pressure regulators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with the ASME Boiler and Pressure Vessel Code.

1.6 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. 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 seven 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.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. 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 2014 Indiana Fuel Gas Code (2012 International Fuel Gas Code).

B. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.

C. Natural-Gas System Pressure within Buildings:

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1. Two pressure ranges. Primary pressure is more than 0.5 psig, but not more than 5 psig, and is reduced to secondary pressure of 0.5 psig or less.

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.

2.3 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.

2.4 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.

2.5 MANUAL GAS SHUTOFF VALVES

A. 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. Service Mark: Valves NPS 1-1/4 to NPS 2 having initials "WOG" permanently marked on valve body.

B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Service Mark: Initials "WOG" permanently marked on valve body.

C. One-Piece, Bronze Ball Valve 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.

2. Body: Bronze, complying with ASTM B584.
3. Ball: Chrome-plated brass.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.

6. Packing: Separate packnut with adjustable-stem packing threaded ends.
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.

D. 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.

2.6 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.
5. downstream and is to not

B. 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. Eclipse Innovative Thermal Technologies.
   e. Fischer; Emerson Electric Co., Automation Solutions.
   f. Itron Inc.

g. Maxitrol Company.
h. Richards Industrials.
i. 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: 2 psig.

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 2012 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.

3.4 INSTALLATION OF INDOOR PIPING

A. Comply with the 2012 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 the equipment connection point 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.

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. 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.

3.5 INSTALLATION OF VALVES

A. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

B. Do not install valves in return-air plenums.

3.6 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.

3.7 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

B. 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.

C. Support horizontal piping within 12 inches of each fitting.

D. Support vertical runs of steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. 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.

3.8 PIPING CONNECTIONS

A. 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.

B. Where installing piping adjacent to appliances, allow space for service and maintenance of appliances.

C. 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.

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Test, inspect, and purge natural gas in accordance with the 2012 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.

3.10 PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 2 and smaller is to be the following:
1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, piping NPS 2-1/2 and larger is to be the following:
1. Steel pipe with wrought-steel fittings and welded joints

C. 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.

3.11 PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

A. Aboveground, piping NPS 2 and smaller is to be the following:
1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, piping NPS 2-1/2 and larger is to be the following:

1. Steel pipe with wrought-steel fittings and welded joints.

3.12 MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter are to be the following:

1. One-piece, bronze ball valve with bronze trim.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter are to be the following:
1. Cast-iron, nonlubricated plug valve.

END OF SECTION 231123

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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. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round ducts and fittings.
4. Double-wall round ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and [ASCE/SEI 7.

B. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

E. 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.

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.

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.

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 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Rectangular Ducts: Fabricate ducts with indicated dimensions for clear internal dimensions of the inner duct.

B. Outer Duct: 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.

C. Transverse Joints: Select joint types and fabricate 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.

D. 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."

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

F. Inner Duct: Minimum 24-gauge perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

2.4 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.

B. 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."

C. 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.

D. 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."

2.5 DOUBLE-WALL ROUND DUCTS AND FITTINGS

A. Round Ducts: Indicated duct sizes on plans are the interior clear dimension of the air path.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. 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."
3. 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."
4. 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."

C. Inner Duct: Minimum 24-gauge perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

D. Interstitial Insulation: Fibrous-glass liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

2.6 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 shall 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: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

2.7 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity:

a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
b. 1-1/2” thickness.

B. Insulation Pins and Washers:

1. 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.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel: with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

a. Fan discharges.
b. Intervals of lined duct preceding unlined duct.
c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

2.8 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall 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: 2 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.

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 (2500 Pa), 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.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.9 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. 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."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

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. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.

L. 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.

M. 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 for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

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. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
3. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

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 interval 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 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.

3.6 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 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 below.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

   a. Pressure Class: Positive 1-inch wg.
   b. Minimum SMACNA Seal Class: C.
   c. SMACNA Leakage Class for Rectangular: 24.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: B.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Equipment Not Listed Above:

   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: B.

c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

4. Concealed supply ducts: Single-wall.
5. Exposed supply ducts in mechanical spaces: Single-wall.
6. Exposed supply ducts in finished spaces: Double-wall, painted. Final color selection by architect.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch w.
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.

3. Concealed return ducts: Single-wall.
4. Exposed return ducts in mechanical spaces: Single-wall.
5. Exposed return ducts in finished spaces: Single-wall, painted. Final color selection by architect.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2-inch wg.
b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 16.
d. SMACNA Leakage Class for Round and Flat Oval: 16.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: C if negative pressure, and B if positive pressure.
c. SMACNA Leakage Class for Rectangular: 16.
d. SMACNA Leakage Class for Round and Flat Oval: 8.

3. Concealed exhaust-air ducts: Single-wall.
4. Exposed exhaust-air ducts in mechanical spaces: Single-wall.
5. Exposed exhaust-air ducts in finished spaces: Single-wall, painted. Final color selection by architect.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 8.
d. SMACNA Leakage Class for Round and Flat Oval: 8.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular:.
d. SMACNA Leakage Class for Round and Flat Oval: 2.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 2.
d. SMACNA Leakage Class for Round and Flat Oval: 2.

4. Concealed outdoor-air ducts: Single-wall.
5. Exposed outdoor-air ducts in mechanical spaces: Single-wall.
6. Exposed outdoor-air ducts in finished spaces: Double-wall, painted. Final color selection by architect.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

G. Liner:

1. Transfer Ducts: Fibrous glass, Type I 0.5-inch thick.

H. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) 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."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) 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.

1) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

I. 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 fpm (5 m/s) or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

PART 1 - PRODUCTS

1.1 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.

1.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Provide products by one of the following:
1. Air Balance Inc.
2. Greenheck.
3. Nailor.
4. NCA Manufacturing.
5. Pottorff.
6. Ruskin.
7. SEMCO.

B. Description: Gravity balanced.

C. Performance:

1. Maximum Air Velocity: 1000 fpm.
2. Maximum System Pressure: 1 inch wg.
3. AMCA Certification: Test and rate in accordance with AMCA 511.
4. Leakage:
   a. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.

D. Construction:

1. Frame:

   a. Hat shaped.
   b. 16-gauge-, with welded or mechanically attached corners and mounting flange.

2. Blades:

   a. Multiple single-piece blades.
   b. Center pivoted, maximum 6-inch width, with sealed edges.

3. Blade Action: Parallel.

E. Blade Seals: Extruded vinyl, mechanically locked or Neoprene, mechanically locked.

F. Blade Axles:

1. Material: Nonferrous metal or Galvanized steel.
2. Diameter: 0.20 inch (5 mm).

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

I. Bearings: Brass sleeve or synthetic pivot bushings.

1.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
1. Provide products by one of the following:
   a. Air Balance Inc.
   b. American Warming & Venting.
   c. Flexmaster.
   d. McGill Airflow.
   e. Metalaire, Inc.
   f. Nailor.
   g. Pottorff.
   h. Ruskin.
   i. Greenheck.
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- (1.6-mm-) 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: Galvanized steel.
7. Bearings:

    a. Oil-impregnated bronze or 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.

1.4 FIRE DAMPERS

A. Provide products by one of the following:
1. Air Balance Inc.
2. Arrow United Industries.
3. Cesco Products.
4. Greenheck Fan Corporation.
5. McGill Airflow LLC.
6. METALAIRE, Inc.
7. Nailor.
8. NCA Manufacturing.
9. PHL, Inc.
10. Pottorff.
11. Ruskin.
12. Ward Industries.

B. Type: Static; rated and labeled in accordance with UL 555 by an NRTL.

C. Fire Rating: 1-1/2 or 3 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. 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.

1.5 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

1.6 TURNING VANES

A. Provide products by one of the following:
1. Ductmate Industries.
2. Duro Dyne.
3. METALAIRE.
4. SEMCO.
5. Ward Industries.

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.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply 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."

D. Vane Construction:

1. Double wall.

1.7 DUCT-MOUNTED ACCESS DOORS

A. 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. 24-gauge- door panel.
    d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
    e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

    a. 24-gauge- (0.70-mm-) thick galvanized steel frame.

3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches (300 mm) 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 with outside and inside handles.
    d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

1.8 FLEXIBLE CONNECTORS

A. 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.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 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.

1.9 DUCT ACCESSORY HARDWARE

A. 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.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

1.10 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60.
2. Exposed-Surface Finish: Mill phosphatized.

B. 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.

C. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 2 - EXECUTION

2.1 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. 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.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

G. Install fire dampers in accordance with UL listing.

H. 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. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke 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.
7. Control devices requiring inspection.
8. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5 inches wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Install duct test holes where required for testing and balancing purposes.

O. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

2.2 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, smoke, and combination fire and smoke 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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ceiling-mounted ventilators.
2. Centrifugal ventilators - roof downblast.

1.2 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.

C. Delegated Design Submittal: For unit hangars and supports 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. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 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. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit 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. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

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: 1.0.

G. Capacities and Characteristics: Refer to schedule on drawings.

2.2 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carnes Company.
2. Greenheck.
3. Loren Cook Company.
4. PennBarry.
5. Twin City Fan & Blower.
6. S&P.

B. Housing: Downblast; removable spun aluminum; square, one-piece aluminum base with venturi inlet cone.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt 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.
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
6. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

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: Manufactured to accommodate roof construction and roof slope.
2. Overall Height: 18 inches unless otherwise noted on drawings.
3. Pitch Mounting: Manufacture curb for roof slope.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

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 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 zinc-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
2. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration 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."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 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."

3.5 STARTUP SERVICE:

A. 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. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
7. Adjust belt tension.
8. Adjust damper linkages for proper damper operation.
9. Verify lubrication for bearings and other moving parts.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. 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.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 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.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233423

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.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. 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.

C. Delegated Design Submittal: For vibration isolation , and seismic restraints 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. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculate requirements for selecting vibration isolators, supports, and seismic restraints.

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. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal 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. Instructions for resetting minimum and maximum air volumes.
b. Instructions for adjusting software set points.

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."

2.2 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Krueger-HVAC.
2. Metalaire.
3. Nailor Industries.
4. Price Industries.
5. Titus.
6. Trane.

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, Flexible Elastomeric" Paragraph.
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, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Velocity Sensors: Multipoint array with velocity inlet sensors.

F. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.
1. SCR controlled.
2. Access door interlocked disconnect switch.
3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
4. Nickel chrome 80/20 heating elements.
5. Airflow switch for proof of airflow.
6. Fan interlock contacts.
7. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).

G. Direct Digital Controls:
1. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, integrated actuators, and room sensors to be furnished under Section 230900 "Direct Digital Control Systems for HVAC" and shipped to terminal unit manufacturer for factory mounting.

H. Control Sequence: See Drawings for control sequences.

2.3 CASING LINER

A. Casing Liner, Flexible Elastomeric: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 1 inch.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.4 SOURCE QUALITY CONTROL

A. AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.

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.

3.2 DUCTWORK CONNECTIONS

A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.3 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."

3.4 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."

3.5 IDENTIFICATION

A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.6 STARTUP SERVICE

A. 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.

3.7 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections :

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
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.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

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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. Rectangular and square ceiling diffusers.
2. Linear slot diffusers.
3. Fixed face registers and grilles.
4. Heavy duty return gym grilles.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to 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. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
2. METALAIRE, Inc.
3. Nailor Industries Inc.
4. Price Industries Limited.
5. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
6. Titus.

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: Aluminum.

D. Finish: Baked enamel, white.

E. Face Size: Refer to schedule on drawings.

F. Face Style: Three cone.

G. Mounting: Surface or T-bar to match ceiling type.

H. Pattern: Adjustable.

I. Accessories: Provide mounting frames, mounting hardware, and accessories as appropriate for ceiling type(s). Refer to schedule on drawings and architectural reflected ceiling plans.

2.2 LINEAR SLOT DIFFUSERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
2. METALAIRE, Inc.
3. Nailor Industries Inc.
4. Price Industries Limited.
5. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
6. Titus.

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material - Shell: Aluminum,.

D. Material - Pattern Controller and Tees: Aluminum.

E. Finish - Face and Shell: Baked enamel, white.

F. Finish - Pattern Controller: Baked enamel, black.

G. Finish - Tees: Baked enamel, white.

H. Pattern Controller: Ice-tong shape for 180-degree air pattern control.

I. Slot Width: Refer to schedule on drawings.

J. Number of Slots: Refer to schedule on drawings.

K. Length: Refer to schedule on drawings.

L. Plenum:

1. Material: Galvanized Steel.
2. Configuration: Side inlet, sloped shoulder for slot diffusers with one to four slots, mounted in ceilings 9'-11" or lower. Refer to schedule on drawings and plans for inlet size and plenum length.
3. Configuration: Side inlet, straight shoulder for slot diffusers with one to four slots, mounted in ceilings 10'-0" and higher. Refer to schedule on drawings and plans for inlet size and plenum length.

M. Accessories: Provide mounting frames, mounting hardware, and accessories as appropriate for ceiling type(s). Refer to schedule on drawings and architectural reflected ceiling plans.

2.3 REGISTERS

A. Fixed Face Register:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
    b. METALAIRE, Inc.
    c. Nailor Industries Inc.
    d. Price Industries Limited.
    e. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
    f. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Horizontal spaced 3/4 inch apart.
5. Core Construction: Integral.
6. Frame: 1-1/4 inches wide.
7. Mounting: Coordinate with ceiling and wall type(s). Refer to schedule on drawings and architectural reflected ceiling and floor plans.
8. Damper Type: Adjustable opposed blade.

2.4 GRILLES

A. Fixed Face Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
    b. METALAIRE, Inc.
    c. Nailor Industries Inc.
    d. Price Industries Limited.
    e. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
    f. Titus.

2. Material: Aluminum.

3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Horizontal; spaced 3/4 inch apart.
5. Core Construction: Integral.
6. Frame: 1-1/4 inches wide.
7. Mounting: Coordinate with ceiling and wall type(s). Refer to schedule on drawings and architectural reflected ceiling and floor plans.

B. Fixed Face Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
   b. METALAIRE, Inc.
   c. Nailor Industries Inc.
   d. Price Industries Limited.
   e. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
   f. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. Face Arrangement: Egg crate.
5. Core Construction: Integral.
6. Frame: 1-1/4 inches wide.
7. Mounting: Coordinate with ceiling and wall type(s). Refer to schedule on drawings and architectural reflected ceiling and floor plans.

C. Heavy Duty Return Gym Grilles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
   b. METALAIRE, Inc.
   c. Nailor Industries Inc.
   d. Price Industries Limited.
   e. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
   f. Titus.

2. Material: Aluminum.
3. Finish: Clear anodized.
4. Face Blade Arrangement: Horizontal; spaced 1/2 inch apart, 30 degree angle.
5. Core Construction: Integral.
6. Frame: 1-1/4 inches wide.
7. Mounting: Coordinate with wall type(s). Refer to schedule on drawings and architectural floor plans.

2.5 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, registers and grilles 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, registers and 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 diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

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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 continuous, tubular, fabric air-distribution devices.

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.

B. Shop Drawings: For fabric air-distribution devices.

1. Include plans, elevations, sections, and suspension and attachment details.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. FabricAir Inc.
2. Prihoda North America.

3. Duct Sox.
4. KE Fibertec.

2.2 PERFORMANCE REQUIREMENTS

A. Continuous tubular diffuser materials shall be listed and labeled as complying with NFPA 90A.

B. Air permeability of fabric will comply with ASTM D737.

2.3 CONTINUOUS TUBULAR DIFFUSERS

A. Description:

1. Fabric: Woven permeable polyester.
2. Shape: Round.
3. Air-Outlet Configuration: Permeable fabric. As indicated on drawings.
4. Air-Outlet Configuration: Circumferential hole pattern with diffusion-hole as specified on drawings. As indicated on drawings
5. Air-Outlet Configuration: Lengthwise mesh. As indicated on drawings
6. Air-Outlet Configuration: Lengthwise hole pattern; with diffusion-hole diameter of. As indicated on drawings
7. Air-Outlet Configuration: Periodic nozzles. As indicated on drawings
8. Air-Outlet Configuration: Linear vents. As indicated on drawings
9. Color: by Architect.

B. Duct Connection Type: Round zipper.

C. Accessories:

1. Quick-connect joint.
2. Snap hooks.
3. Cleanout zipper.
4. Condensate drain.
5. Fabric damper.
6. End cap.
7. Draw cords.
8. Removable support hoops.
9. Elbows.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet 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. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

END OF SECTION 233716

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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, large-capacity, rooftop air conditioning units (RTUs) with the following components and accessories:

1. Casings.
2. Fans.
3. Motors.
4. Coils.
5. Rotary Heat Exchanger.
6. Fixed-plate Heat Exchanger.
7. Refrigerant circuit components.
8. Air filtration.
9. Gas furnaces.
10. Dampers.
11. Electrical power connections.
12. Controls.
13. Accessories
14. Roof curbs.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electronically commutated motor.

C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

D. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

E. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

F. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.4 ACTION SUBMITTALS

A. Product Data, Shop Drawings, and Delegated Design Submittal:

1. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

2. Shop Drawings:

a. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Include diagrams for power, signal, and control wiring.

3. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
?. Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: 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:

1. Structural members to which RTUs will be attached.
2. Roof openings.
3. Roof curbs and flashing.

B. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

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.

C. Field quality-control reports.

D. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set(s) for each belt-driven fan.
2. Filters: Three spare set(s) of filters for each unit.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.
5. Warranty Period for UVGI System: Lifetime with exception of lamps.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. AHRI Compliance:

1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.
4. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested in accordance with AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with 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. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

F. UL Compliance: Comply with UL 1995.

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.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. reenheck
2. Trane.
3. Carrier.
4. Valent.

2.3 CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction:

a. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
b. Inside Casing Wall: G90-coated galvanized steel, 0.034 inch thick.
c. Floor Plate: G90 galvanized steel, minimum 18 gauge thick.
d. Casing Insulation:

1) Materials: Injected polyurethane foam insulation.
2) Casing Panel R-Value: Manufacturer’s standard.
3) Insulation Thickness: 2 inches.
4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

C. Drain Pans: Fabricated using stainless 0.025 inches thick steel sheet, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

A. Static-Pressure Classification:

1. For Unit Sections Upstream of Fans: Minus 2-inch wg.
2. For Unit Sections Downstream and Including Fans: 2-Inch wg.

2.4 FANS

A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
2. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.

B. Condenser-Coil Fan: propeller, mounted on shaft of permanently lubricated motors.

2.5 MOTORS

A. Comply with NEMA MG 1, Design B, medium induction motor, unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

C. 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.

D. Duty: Continuous duty at ambient temperature of 104 deg F and at altitude of 3300 feet above sea level.

E. 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.

F. Efficiency: Energy efficient, as defined in NEMA MG 1.

G. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements.

H. 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.

I. Multispeed Motors: Separate winding for each speed.

J. Rotor: Random-wound, squirrel cage.

K. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

L. Temperature Rise: Match insulation rating.

M. Insulation: Class F.

N. 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.

O. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

P. 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.

Q. 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. 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.

2.6 COILS

A. Supply-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Coil Split: Interlaced.
3. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.

B. Outdoor-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.

2.7 ROTARY HEAT EXCHANGER

A. Heat exchanger integral to unit.

B. Casing:

1. Galvanized steel, stainless steel, or aluminum with manufacturer’s standard factory-painted finish.

2. Integral puge 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.
3. Casing seals on periphery of rotor and on duct dividider and purge section.
4. Support vertical rotor on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearings.

C. Rotor-Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.

D. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with a L-10.

E. Controls:

1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2. 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. Rotor speed is to increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
3. Control energy recovery to permit air economizer operation.

    a. Bypass dampers to assist energy recovery control.

4. Pilot-Light Indicator: Display rotor rotation and speed.
5. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
6. Defrost Cycle.

2.8 FIXED-PLATE HEAT EXCAHNGER

A. Type: Total energy-recovery unit.

B. Casing: Aluminum, stainless steel, or Galvanized steel with manufacturer’s standard factory-painted finish.

C. Drain Pan: Same material as casing, with drain connections on exhaust and supply side.

1. Comply with requirements in ASHRAE 62.1.

D. Plates: Evenly spaced, sealed, and arranged for counter airflow.

1. Plate Material and Coating: Chemically treated paper, or polymer on aluminum, with selective hygroscopicity, moisture permeability, and gas barrier properties.

E. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.

F. Maximum Differential Pressure: Suitable for maximum 6-inch wg.

G. Maximum Temperature: Suitable for maximum 194 deg F.

2.9 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: Two.

B. Compressor: Hermetic, variable speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

C. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low-ambient kit high-pressure sensor.
10. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.
11. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.10 AIR FILTRATION

A. Minimum arrestance and a minimum efficiency reporting value according to ASHRAE 52.2 with pleated media.

B. Pleated Panel Filters:

1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
2. Filter Unit Class: UL 900, .
3. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.

a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
b. Adhesive: As recommended by air-filter manufacturer and that 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. Media shall be coated with an antimicrobial agent.
d. Separators shall be bonded to the media to maintain pleat configuration.
e. Welded-wire grid shall be on downstream side to maintain pleat.
f. Media shall be bonded to frame to prevent air bypass.
g. Support members on upstream and downstream sides to maintain pleat spacing.

2.11 GAS FURNACES

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel.

1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel.

D. Venting: Gravity vented with vertical extension.

E. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension.

F. Safety Controls:

1. Gas Control Valve: Modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.12 DAMPERS

A. Outdoor-Air Damper: Linked damper blades, for 0 to 100percent outdoor air, with motorized damper filter.

B. Outdoor- and Return-Air Mixing Dampers: blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage or gears and interconnect so dampers operate simultaneously.

1. Leakage Rate: As required by ASHRAE/IES 90.1.
2. Damper Motor: Modulating with adjustable minimum position.
3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1, with bird screen and hood.

C. Relief dampers.

2.13 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.14 CONTROLS

A. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted temperature sensor with the following features:

    a. Exposed set point.
    b. Unoccupied-period-override push button.

B. Electronic DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:

    a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
    b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire alarm control panel.
    c. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 283111 "Digital, Addressable Fire-Alarm System" and Section 283112 "Zoned (DC Loop) Fire-Alarm System."
    d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F.

3. Unoccupied Period:

    a. Heating Setback: 8 deg.
    b. Cooling Setback: 8 deg.
    c. Override Operation: Two hours, adjustable.

4. Supply Fan Operation:

    a. Occupied Periods: Run fan continuously.
    b. Unoccupied Periods: Cycle fan to maintain setback temperature.

5. Refrigerant Circuit Operation:

    a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain room temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
    b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
    c. Switch reversing valve for heating or cooling mode on air-to-air heat pump.

6. Hot-Gas Reheat-Coil Operation:

    a. Occupied Periods: Humidity sensor opens hot-gas valve to provide hot-gas reheat, and cycles compressor.

7. Gas Furnace Operation:

    a. Occupied Periods: Modulate burner to maintain room temperature.
    b. Unoccupied Periods: Cycle burner to maintain setback temperature.

8. Electric-Heating-Coil Operation:

    a. Occupied Periods: Modulate coil to maintain room temperature.
    b. Unoccupied Periods: Energize coil to maintain setback temperature.
    c. Operate supplemental electric heating coil with compressor for heating with outdoor temperature below 25 deg F.

9. Outdoor-Air Damper Operation:

    a.
    b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

10. Carbon Dioxide Sensor Operation:

    a. Occupied Periods: Reset minimum outdoor-air ratio down to minimum 0 percent to maintain maximum 1000-ppm concentration in the return duct.
    b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

11. Terminal-Unit Relays:

    a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

C. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface for central HVAC control workstation for the following:

    a. Adjusting set points.
    b. Monitoring supply fan start, stop, and operation.
    c. Inquiring data to include damper position, supply- and room-air temperature, carbon dioxide and humidity.
    d. Monitoring occupied and unoccupied operations.
    e. Monitoring constant and variable motor loads.
    f. Monitoring variable-frequency drive operation.
    g. Monitoring cooling load.
    h. Monitoring economizer cycles.
    i. Refer to Temperature Control drawings for additional requirements.

2.15 ACCESSORIES

A. Un-powered, Duplex, 115-V, ground-fault-interrupter outlet with 20-A overcurrent protection. Receptacle will be powered by separate circuit by DIV 26.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

C. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss reversal protection.
4. High and low pressure control.
5. Airflow-proving switch.

D. Coil guards of painted, galvanized-steel wire.

E. Hail guards of galvanized steel, painted to match casing.

F. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.

G. Door switches to disable heating or reset setpoint when open.

H. Outdoor air intake weather hood.

I. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

2.16 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C 1071, Type I or II.
b. Thickness: 2 inches.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

a. Liner Adhesive: Comply with ASTM C 916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C 916, Type I.
e. Curb Dimensions: Height of 18 inches unless noted otherwise on drawings.

END OF SECTION 237416.13

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 split-system heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed mounting.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics. B. Shop Drawings: Diagram power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

1.5 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide LG or a comparable product by one of the following:

   1. LG.
   2. Mitsubishi.
   3. Panasonic.
   4. Carrier.

2.3 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve. C. Fan: Direct drive, centrifugal fan.

D. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

   1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

E. Filters: Permanent, cleanable.

2.4 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gauge ports on exterior of casing.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

1. Compressor Type: Per Manufacturer

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.

E. Fan: Aluminum-propeller type, directly connected to motor.

F. Motor: Permanently lubricated, with integral thermal-overload protection.

G. Mounting Base: Equipment rails or curb on roof.

2.5 ACCESSORIES

A. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and on the drawings.

B. Thermostat: Low voltage to control compressor and evaporator fan.

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection, including auto setting.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

E. Condensate pump for removal of condensate from wall mounted unit. Pump to be wired into power feed for indoor unit. Manufacturer to supply pump and wiring diagram for contractor for contractor to assure proper connection and operation.

F. Provide accessories as required to allow low-ambient operation down to -4F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounting, compressor-condenser components on 4-inch thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install roof-mounting compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmiumplated fasteners.

E. Install seismic restraints.

F. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

G. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

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.

C. Remove and replace malfunctioning units and retest as specified above.

3.4 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.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238126

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Wall and ceiling unit heaters with propeller fans and electric-resistance heating coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. 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 details of anchorages and attachments to structure and to supported equipment.
4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 WALL AND CEILING UNIT HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Berko; Marley Engineered Products.
2. Chromalox, Inc.
3. INDEECO.
4. Markel Products Company; a subsidiary of TPI Corporation.
5. Marley Engineered Products.
6. QMark; Marley Engineered Products.

B. Heaters: Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

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.

2.2 CABINET

A. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.

B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

C. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.

D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.3 COIL

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.4 FAN AND MOTOR

A. Fan: Aluminum propeller directly connected to motor.

B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230500 "Common Work Results for HVAC."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

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

3.2 INSTALLATION OF WALL AND CEILING UNIT HEATERS

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall and ceiling unit heaters level and plumb.

C. 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.

D. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

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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. Electrical equipment coordination and installation.
2. Codes and standards.
3. Work and workmanship.
4. Drawings and minor deviations.
5. Continuous operations.
6. Grout.
7. Common electrical installation requirements.
8. Miscellaneous work.
9. Protection and treatment of property.
10. Electrical connections to equipment.
11. Temporary lighting and power.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 COORDINATION

A. 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 equipment with minimum interference to other installations.

3. To allow right of way for piping and conduit installed at required slope.

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Rough-in: Verify exact location of rough-in prior to installation, checking mounting heights with equipment manufacturers or casework suppliers.

E. Each Contractor and subcontractor shall study all Drawings applicable to this work so complete coordination between trades will be affected. Special attention shall be given to points where ducts cross and where pipes, ducts, and conduit pass through walls.

F. It is responsibility of each Contractor and Subcontractor to leave necessary room for other trades. No extra compensation will be allowed to cover cost of removing piping, conduit, ducts, or equipment found encroaching on space required by others.

1.5 CODES AND STANDARDS

A. All materials and workmanship shall comply with all applicable Codes, Specifications, local ordinances, industry standards, and utility company regulations.

B. In case of difference between building codes, specifications, state laws, local ordinances, industry standards, utility company regulations, and Contract Documents, most stringent shall govern. Contractor shall promptly notify Architect/Engineer in writing of such difference.

C. Non-Compliance: Should Contractor perform Work that does not comply with requirements of applicable building codes, state laws, local ordinances, industry standards, and utility company regulations, Contractor shall bear all costs related to correcting deficiencies.

D. Applicable codes and standards shall include all state laws, local ordinances, utility company regulations and applicable requirements of following nationally accepted codes and standards.

E. Building codes (with all state and local amendments) shall include, but not be limited to following:

1. National Electrical Code.
2. International Building Code.
3. Indiana Accessibility Code.
4. International Fire Code.
5. International Mechanical Code.
6. International Plumbing Code.
7. Indiana Accessibility Code.

F. These requirements shall be considered minimum and shall be exceeded when so indicated on Drawings or herein specified.

G. Permits: Contractor shall pay for all building permits required by the Work, permits for opening streets, and for connection to various utilities, including fees for electric meter installation and other requirements necessary to carry out the Work.

H. Where streets or sidewalks are cut, they shall be repaired to at least as good a condition as they were before, all at expense of this Contractor. Permits shall be posted in a prominent place at building Site properly protected from weather and physical damage.

I. Industry Standards, Codes and Specifications

1. IEEE: Institute of Electrical and Electronic Engineers.
2. ASA: American Standards Association.
3. ASTM: American Society of Testing Materials.
4. IPCEA: Insulated Power Cable Engineers Association.
5. NBS: National Bureau of Standards.
6. NEMA: National Electric Manufacturers Association.
7. NFPA: National Fire Protection Association.
8. UL: Underwriters Laboratories.
9. NECA: National Electrical Contractors Association.
10. OSHA: Occupational Safety and Health Act.

J. Occupancy Safety and Health Standards

1. All Work shall comply with current requirements of U.S. Department of Labor Occupational Safety and Health Administration, entitles Occupational Safety and Health Standards; National Consensus Standards and Established Federal Standards.

K. Work and Workmanship

1. Provide all required labor, materials, equipment and Contractor's services necessary for complete installation of systems required in full conformity with requirements of authorities having jurisdiction; all as indicated on Drawings and herein specified.

2. Finished job shall be functional and complete in every detail including all such items required for complete system, whether or not these items are specified or shown on Drawings.

3. Special attention shall be given to accessibility of working and controlling parts. Adjustable parts shall be within easy reach. Removable parts shall have space for removal.

4. Each Contractor shall become fully acquainted with details of all Work to be performed by other trades and take necessary steps to integrate and coordinate its work with other trades.

5. Wherever tables or schedules show quantities of materials, they shall not be used as a final count. These figures are provided only as a guide to Contractor. Each Contractor shall be responsible for furnishing all materials on Drawings or as specified.

6. Owner and Architect/Engineer have full power to reject Work, materials, or equipment not in accordance with these Specifications and Drawings or are not in compliance with manufacturer's specifications or drawings which are approved by Owner or Architect/Engineer.

7. Work or equipment that is rejected shall be removed and replaced to satisfaction of Owner, at Contractor's expense. Work or equipment that is rejected shall be so stated in writing by Owner or Architect/Engineer.

8. Decisions that Owner or Architect/Engineer may make with respect to questions concerning quality, fitness of materials, equipment, and workmanship shall be binding upon parties and entities involved in that Work.

L. Drawings and Minor Deviations

1. Electrical Drawings show general arrangement of all raceways, equipment, and appurtenances. They shall be followed as closely as actual building construction and Work of other trades will permit. Electrical Work shall conform to requirements shown on all Drawings. Because of small scale of Electrical Drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Contractor shall investigate structural and finish conditions affecting Work and shall arrange its Work accordingly, providing such fittings and accessories as may be required to meet such conditions.

2. In event of conflict of requirements detailed in Drawings, General Conditions, these General Provisions and subsequent sections of these Specifications, Bidder shall inform Architect/Engineer of such conflict in writing not later than 5 days before bids are due. If such notification is not provided, Contractor shall accept Architect/Engineer's decision to resolve such conflict without further compensation.

3. For purpose of clarity and legibility, Drawings are essentially diagrammatic, although size and location of equipment and piping are drawn to scale wherever possible. Verify Contract Documents information at Site.

4. Drawings indicate required sizes and points of termination of conduits and ducts and suggest routes. It is not intention of Drawings to indicate all necessary offsets. Install work in manner to conform to structure, avoid obstructions, preserve headroom, and keep openings and passageways clear. Do not scale from Drawings.

M. Continuous Operations

1. All Work shall be performed in a manner that allows Owner to operate existing facility on continuous basis. Temporary feeders or branch circuits shall be provided as required to maintain continuous operation of Owner's facility.

2. Should an outage be required, Contractor shall submit work procedure 5 working days before outage. Work procedure shall indicate step by step procedure which Contractor expects to follow to perform its work. Each shall indicate condition of power source, commercial or diesel, calendar day and time of day from commencement to completion of work. All outages shall be scheduled at Owner's convenience. Contractor shall include all overtime pay for workmen in its Bid.

PART 2 - PRODUCTS

2.1 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

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 center of unit for wall-mounting 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 these requirements.

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.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.3 MISCELLANEOUS WORK

A. Painting

1. Touch-up existing equipment where finishes are marred or damaged due to construction Work.

B. Special Coatings

1. Equipment furnished with factory-applied finish shall be protected from damage by installing Contractor. Damaged surface shall be repaired by installing Contractor to match original finish or shall be replaced with new before final acceptance.

C. Floor and Wall Openings

1. Floor and wall openings for electrical Work shall be provided by Electrical Contractor.
2. Final sizes and exact locations of electrical penetrations in floor and wall openings are responsibility of Electrical Contractor.

D. Roof Openings

1. Roof openings for electrical Work shall be provided by General Contractor, if shown on Architectural or Structural Drawings. Openings not shown on Architectural Drawings shall be provided by Electrical Contractor.

2. Final sizes and exact locations of electrical penetrations through roof structure are responsibility of Electrical Contractor.

3. Roof flashing and equipment counterflashing shall be provided by Electrical Contractor.

E. Concrete Bases

1. Concrete bases for electrical equipment shall be provided by Electrical Contractor.

2. Concrete bases shall comply with requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

F. Concrete Light Fixture Pole Bases

1. Concrete pole bases for light fixtures shall be provided by Electrical Contractor.

2. Concrete pads shall comply with requirements specified in Division 26 Section "Exterior Lighting."

G. Platforms and Supports

1. Platforms and supporting stands shall be provided by Electrical Contractor for their respective equipment.

2. Each piece of equipment or apparatus suspended from ceiling or mounted above floor level shall be provided with suitable structural support, platform, or carrier in accordance with best recognized practice.

3. Contractors shall exercise extreme care that structural members of building are not overloaded by such equipment. In all cases, details of such hangers, platforms and supports together with total weights of mounted equipment shall be approved by Structural Engineer.

4. Provide all structural supports for proper attachment of electrical equipment supplied and also for equipment such as motor controllers, supplied as Work of other Divisions or by Owner for mounting connection and installation in this Division.

5. Concrete pads shall comply with requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

H. Access Doors

1. Electrical Contractor shall provide all access doors required for access to electrical equipment. Access doors shall comply with requirements specified in Division 8 Section "Access Doors and Frames."

I. Cutting and Patching

1. Electrical Contractor shall provide all cutting and patching required for installation of new conduit and wiring. Cutting and patching shall comply with requirements of Division 1 Section "Cutting and Patching."

J. Excavation and Backfilling

1. Electrical Contractor shall provide all excavation and backfilling required for installation of new electrical equipment. Excavation and backfilling shall comply with requirements of Division 31.

K. Dust Protection

1. Temporary partitions or barriers required to protect existing building or facilities shall be provided by General Contractor. General Contractor shall coordinate necessity and location of such protection with Owner. Electrical Contractor shall maintain clean work area with daily sweeping.

2. Electrical Contractor shall provide dust protection for operations requiring same which are in addition to those shown on Drawings. Dust partitions or barriers are required to protect existing equipment. Contractor's operations which could cause dust shall be performed with dust barriers erected.

3.4 PROTECTION AND TREATMENT OF PROPERTY

A. Repair and replace with new all property damaged in installation of underground lines to meet approval of Owner and authorities having jurisdiction.

B. Replace base and wearing surfaces of streets with same kind and thickness of material as existing. Replace brick, concrete, and asphalt surface to width 6 inches wider than disturbed area. Replace entire surface, if more than 30% has been disturbed.

C. Replace sidewalks, curbs, gutters, and driveways with same kind of thickness of materials. Replace entire section of concrete walks or driveways.

D. Regrade and replant lawn areas.

E. Protect existing utilities. Cap existing utilities that are abandoned.

3.5 ELECTRICAL CONNECTIONS TO EQUIPMENT

A. In event that supplier of equipment requires a larger starter or disconnect than those indicated in Documents, that supplier shall reimburse Contractor difference in cost for supplying these items.

B. Connections and wiring diagrams shown on Drawings or described in Specifications are typical and are for bidding purposes only. Detailed diagrams and instructions shall be provided by Contractor supplying equipment, if connections are different from those shown on Drawings.

C. Additional relays, switches, contactors, etc. which may be required for control purposes in addition to those specified for and indicated on Drawings shall be provided by Mechanical Contractor and its subcontractors. These devices shall be mounted by supplier within 5 feet of apparatus to be installed. Electrical Contractor shall provide all additional conduit, wire, and electrical connections without additional charge to Owner.

D. Wiring diagrams shall be specially drawn so they will specifically apply to this Project. "Typical" wiring diagrams will not be acceptable for installation purposes. In event that several pieces of mechanical equipment from different suppliers are combined into one system, Mechanical Contractor shall furnish complete wiring and control diagram to enable Electrical Contractor to make proper connection. Diagrams shall be submitted to Architect/Engineer for approval before actual wiring.

E. Mechanical Contractor shall furnish to Electrical Contractor written notice of approval and acceptance of all control wiring installed for mechanical system by Electrical Contractor. Such approval shall be given within 30 days of completion of all such control wiring. Two copies of letter shall be sent to Architect/Engineer.

3.6 TEMPORARY LIGHTING AND POWER

A. Electrical Contractor shall arrange for and provide a temporary electrical service for Project as indicated in Division 01.

END OF SECTION 260500

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Fire-alarm wire and cable.
3. Connectors, splices, and terminations rated 600 V and less.

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 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.3 INFORMATIONAL SUBMITTALS

A. 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, provide products by one of the following:

1. Encore Wire Corporation.
2. General Cable; Prysmian Group North America.
3. Southwire Company, LLC.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. 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 for stranded conductors.

E. Conductor Insulation:
1. Type THHN andType THWN-2: Comply with UL 83.
2. Type THW andType THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
3. Type XHHW-2: Comply with UL 44.

2.2 FIRE-ALARM WIRE AND CABLE

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. Southwire Company, LLC.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

NFPA 70 permits wire sizes down to No. 16 AWG.

C. Signaling Line Circuits: Twisted, shielded pair, **not less than No. 18 AWG**.

Retain "Circuit Integrity Cable" Subparagraph below if use of cable is an option.

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.

NFPA 70 permits wire sizes down to No. 18 AWG.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.

Retain "Multiconductor Armored Cable" Subparagraph below if use of cable is an option.

3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/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.

2.3 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, provide products by one of the following:

1. Hubbell Utility Solutions; Hubbell Incorporated.
2. Ideal Industries, Inc.
3. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: One hole with standard barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits:

1. Copper, Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: 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. 260543Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

3.3 260543INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533.13 "Conduits for Electrical Systems" prior to pulling conductors and cables.

C. 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.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 280528CONNECTIONS

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.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.

3.5 **284621284621**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.

3.6 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."

3.7 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 078413 "Penetration Firestopping."

END OF SECTION 260519

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PART 1 - PRODUCTS

1.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1.2 260519GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.

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.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Arlington Industries, Inc.
c. Cooper B-line; brand of Eaton, Electrical Sector.
d. Crouse-Hinds; brand of Eaton, Electrical Sector.
e. ERICO; brand of nVent Electrical plc.
f. Galvan Industries, Inc.; Electrical Products Division, LLC.
g. Harger Lightning & Grounding; business of Harger, Inc.
h. ILSCO.
i. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
j. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics:

a. Two pieces with zinc-plated bolts.
b. Clamp Material: Silicon bronzez .
c. Listed for outdoor use.

1.3 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Arlington Industries, Inc.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Threaded bushing with insulated throat.

D. UL KDER - Grounding Bushing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Arlington Industries, Inc.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

1.4 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Arlington Industries, Inc.
c. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Crouse-Hinds; brand of Eaton, Electrical Sector.
e. Greaves Corp.; Essex Products Group, Inc.
f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
g. Penn-Union Corp.; subsidiary of Nesco, Inc.

2. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

1.5 GROUNDING AND BONDING CONNECTORS

A. 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.

b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

B. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. ERICO; brand of nVent Electrical plc.
c. Greaves Corp.; Essex Products Group, Inc.
d. allG Fabrication (formerly ALT).
e. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened.

a. Copper.

1.6 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Chatsworth Products, Inc.
b. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
c. Cooper B-line; brand of Eaton, Electrical Sector.
d. ERICO; brand of nVent Electrical plc.
e. allG Fabrication (formerly ALT).
f. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. 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.

3. Options:

a. Dimensions: 1/4 by 4 inch in cross section; length as indicated on Drawings.
b. Predrilled Hole Pattern: 9/32 inch holes spaced 1-1/8 inch apart. Suitable for installing specified grounding and bonding connectors.
c. Mounting Hardware: Stand-off brackets that provide 2 inch clearance to access rear of bus. Brackets and bolts must be stainless steel.

1.7 GROUNDING (EARTHING) 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. UL KDER - Rod Electrode:

1. <Double click here to find, evaluate, and insert list of manufacturers and products>
2. General Characteristics: Copper-clad; 3/4 inch by 10 ft.

PART 2 - EXECUTION

2.1 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR ELECTRICAL POWER

A. Grounding and Bonding Conductors:

1. Provide solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
3. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.

5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
7. Underground Grounding Conductors: Install bare tinned-copper conductor, 2/0 AWG minimum.

B. Grounding and Bonding Connectors:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.

2.2 INSTALLATION OF GROUNDING AND BONDING FOR ELECTRICAL POWER

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. 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.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Grounding and Bonding Conductors:

a. 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. Underground Grounding Conductors:

1) Bury at least 30 inch below grade.

2. Grounding and Bonding Connectors: 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.

a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
b. Make connections with clean, bare metal at points of contact.
c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

f. 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 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 for outdoor locations; if disconnect-type connection is required, use bolted clamp.

g. 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 bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where 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 bolted connector.
3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3. Grounding and Bonding Busbars:

a. Install busbar horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.

4. Electrodes:

a. 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 for below-grade connections.

b. WConcrete-Encased Electrode (Ufer Ground):

1) Fabricate in accordance with NFPA 70; use minimum of 20 ft of bare copper conductor not smaller than 4 AWG.

a) If concrete foundation is less than 20 ft 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 long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.

5. Grounding Separately Derived Systems:

a. Generator: Install grounding electrode(s) at generator location. Electrode must be connected to equipment grounding conductor and to frame of generator.

6. Grounding Underground Distribution System Components:

a. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.
b. Comply with IEEE C2 grounding requirements.
c. Grounding Manholes and Handholes: Install 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 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with 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.

7. Equipment Grounding:

a. Install insulated equipment grounding conductors with feeders and branch circuits.
b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1) Feeders and branch circuits.
2) Lighting circuits.
3) Receptacle circuits.
4) Single-phase motor and appliance branch circuits.
5) Three-phase motor and appliance branch circuits.
6) Flexible raceway runs.
7) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
d. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

e. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

2.3 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING OF ELECTRICAL POWER

A. Field tests and inspections must be witnessed by Architect.

B. 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 calibrated torque wrench in accordance with manufacturer's published instructions.
3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
    c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

C. Nonconforming Work:

1. Grounding system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective components and retest.

D. Collect, assemble, and submit test and inspection reports.

1. Report measured ground resistances that exceed the following values:

    a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω.
    b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω.
    c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 Ω.
    d. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 Ω.
    e. Substations and Pad-Mounted Equipment: 5 Ω.

2.4 FIELD QUALITY CONTROL FOR BONDING OF COMMUNICATIONS

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench according to manufacturer's published instructions.

C. Collect, assemble, and submit test and inspection reports.

2.5 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260526

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Support, anchorage, and attachment components.
2. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, 260010 and other Project requirements applicable to Work specified in this Section.

1.2 260011ACTION SUBMITTALS

A. Product Data: For each type of product.

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 Submittals: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design hanger and support system.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allied Tube & Conduit; Atkore International.
    b. Atkore Unistrut.
    c. CADDY; brand of nVent Electrical plc.
    d. Cooper B-line; brand of Eaton, Electrical Sector.
    e. Haydon Corporation.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

B. Conduit and Cable Support Devices: Steel 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, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Cooper B-line; brand of Eaton, Electrical Sector.
        2) Empire Industries, Inc.
        3) Hilti, Inc.
        4) ITW Ramset/Red Head; Illinois Tool Works, Inc.

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: All steel springhead type.
6. Hanger Rods: Threaded steel.

PART 3 - 055000EXECUTION

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

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

D. Comply with requirements for boxes specified in Section 260533.16 "Boxes and Covers for Electrical Systems."

E. **260548260548**Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as scheduled in NECA NEIS 1, where its Table 1 lists maximum spacings that are less than those stated in 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 or other 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.

G. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

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 must be weight of supported components plus 200 lb.

C. 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. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inch thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
7. To Light Steel: Sheet metal screws.
8. 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.

D. 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.

END OF SECTION 260529

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT-S duct raceways and elbows.
2. Type HDPE duct raceways and fittings.
3. Type ERMC-S duct raceways, elbows, couplings, and nipples.
4. Type FMC-S duct raceways. See restrictions on use in sections 3.1 and 3.2.
5. Type IMC duct raceways.
6. Type LFMC duct raceways. See restrictions on use in sections 3.1 and 3.2.
7. Type PVC duct raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Electrically conductive corrosion-resistant compounds for threaded conduit.
10. Solvent cements.

B. Products Installed, but Not Furnished, under This Section:

1. See Section 260553 "Identification for Electrical Systems" for electrical equipment labels.

C. Related Requirements:

1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.260010
2. 260011Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" for nonmetallic underground conduit with conductors (Type NUCC).
3. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.

1.2 DEFINITIONS

A. Conduit: A structure containing one or more duct raceways.

B. Duct Raceway: A single enclosed raceway for conductors or cable.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Type EMT-S duct raceways and elbows.
2. Type HDPE duct raceways and fittings.
3. Type ERMC-S duct raceways, elbows, couplings, and nipples.
4. Type FMC-S duct raceways. See restrictions on use in sections 3.1 and 3.2.

5. Type IMC duct raceways.
6. Type LFMC duct raceways. See restrictions on use in sections 3.1 and 3.2.
7. Type PVC duct raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Electrically conductive corrosion-resistant compounds for threaded conduit.
10. Solvent cements.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions:

1. Type EMT-S duct raceways and elbows.
2. Type HDPE duct raceways and fittings.
3. Type ERMC-S duct raceways, elbows, couplings, and nipples.
4. Type FMC-S duct raceways. See restrictions on use in sections 3.1 and 3.2.
5. Type IMC duct raceways.
6. Type LFMC duct raceways. See restrictions on use in sections 3.1 and 3.2.
7. Type PVC duct raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Electrically conductive corrosion-resistant compounds for threaded conduit.
10. Solvent cements.

PART 2 - PRODUCTS

2.1 TYPE EMT-S DUCT RACEWAYS AND ELBOWS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN FJMX; including UL 797.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL FJMX - Steel Electrical Metal Tubing (EMT-S) and Elbows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Republic Conduit; Nucor Corporation, Nucor Tubular Products.

c. Western Tube; Zekelman Industries.

2. Wheatland Tube; Zekelman Industries.Material: Steel.
3. Options:

a. Interior Coating: Zinc.
b. Minimum Trade Size: Trade size 3/4.

2.2 TYPE HDPE DUCT RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN EAZX; including UL 651A.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL EAZX - Schedule 40 Electrical HDPE Underground Conduit (HDPE-40):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Blue Diamon Industries
b. Prysmian Cables and Systems; Prysmian Group North America
c. Southwire Company, LLC

2. Dimensional Specifications: Schedule 40.
3. Options:

a. Minimum Trade Size: Trade size 1.

D. UL EAZX - Schedule 80 Electrical HDPE Underground Conduit (HDPE-80):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Blue Diamon Industries
b. Prysmian Cables and Systems; Prysmian Group North America
c. Southwire Company, LLC

2. Dimensional Specifications: Schedule 80.

3. Options:

    a. Minimum Trade Size: Trade size 1.

2.3 TYPE ERMC-S DUCT RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN DYIX; including UL 6.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DYIX - Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Allied Tube & Conduit; Atkore International.
    b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    c. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    d. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
    e. Western Tube; Zekelman Industries.
    f. Wheatland Tube; Zekelman Industries.

2. Exterior Coating: Zinc.
3. Options:

    a. Interior Coating: Zinc.
    b. Minimum Trade Size: Trade size 1.
    c. Colors: As indicated on Drawings.

2.4 TYPE FMC-S DUCT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN DXUZ; including UL 1.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DXUZ - Steel Flexible Metal Conduit (FMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Anaconda Sealtite; Anamet Electrical, Inc.
c. Electri-Flex Company.
d. International Metal Hose Co.
e. Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway.

2. Material: Steel.
3. Options:

a. Minimum Trade Size: Trade size 3/4.

2.5 TYPE IMC DUCT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN DYBY; including UL 1242.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DYBY - Steel Intermediate Metal Conduit (IMC):

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. Republic Conduit; Nucor Corporation, Nucor Tubular Products.

d. Western Tube; Zekelman Industries.
e. Wheatland Tube; Zekelman Industries.

2. Options:

a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Trade size 3/4.

2.6 TYPE LFMC DUCT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN DXHR; including UL 360.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DXHR - Steel Liquidtight Flexible Metal Conduit (LFMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Anaconda Sealtite; Anamet Electrical, Inc.
c. Electri-Flex Company.
d. International Metal Hose Co.

2. Material: Steel.
3. Options:

a. Minimum Trade Size: Trade size 3/4.

2.7 TYPE PVC DUCT RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN DZYR; including UL 651.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DZYR - Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Calconduit; Atkore International.
c. NAPCO; Westlake Chemical Corp.
d. Opti-Com Manufacturing Network, Inc (OMNI).

2. Dimensional Specifications: Schedule 40.
3. Options:

a. Minimum Trade Size: Trade size 1.
b. Markings: For use with maximum 90 deg C wire.

D. UL DZYR - Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Calconduit; Atkore International.
c. JM Eagle.
d. Opti-Com Manufacturing Network, Inc (OMNI).

2. Dimensional Specifications: Schedule 80.
3. Options:

a. Minimum Trade Size: Trade size 1.
b. Markings: For use with maximum 90 deg C wire.

2.8 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: 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.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DWTT - Fittings for Type ERMC, Type IMC, Type PVC, and Type HDPE:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. ABB, Electrification Business.
   b. Crouse-Hinds; brand of Eaton, Electrical Sector.
   c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   d. Southwire Company, LLC.

2. Listing Criteria: UL CCN DWTT; including UL 514B.
3. Options:

   a. Material: Steel.
   b. Coupling Method: Compression coupling.
   c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

D. UL FKAV - Fittings for Type EMT Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Allied Tube & Conduit; Atkore International.
   b. Appleton; Emerson Electric Co., Automation Solutions.
   c. Crouse-Hinds; brand of Eaton, Electrical Sector.
   d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Listing Criteria: UL CCN FKAV; including UL 514B.
3. Options:

   a. Material: Steel.
   b. Coupling Method: Compression coupling.
   c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

E. UL DXAS - Fittings for Type LFMC Duct Raceways:

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. Arlington Industries, Inc.
   b. Liquid Tight Connector Co.

2. Listing Criteria: UL CCN DXAS; including UL 514B.

2.9 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN FOIZ; including UL Subject 2419.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL FOIZ - Electrically Conductive Corrosion-Resistant Compound for Threaded Conduit:

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. ABB, Electrification Business.

2.10 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN DWTT; including UL 514B.

B. UL DWTT - Solvent Cements for Type PVC Duct Raceways and Fittings:

PART 3 - EXECUTION

3.1 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.

B. Outdoors:

1. Exposed and Subject to Severe Physical Damage: ERMC.
2. Exposed and Subject to Physical Damage: ERMC or IMC.

    a. Locations less than 2.5 m (8 ft) above finished floor.

3. Exposed and Not Subject to Physical Damage: IMC.
4. Concealed Aboveground: IMC or EMT .
5. Direct Buried: PVC-80, PVC-40, HDPE-80 or HDPE-40.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.

C. Indoors:

1. Exposed and Subject to Severe Physical Damage: ERMC. Locations include the following:
    a. Mechanical rooms.
    b. Gymnasiums.

2. Exposed and Subject to Physical Damage: ERMC, IMC, or EMT. Locations include the following:

    a. Locations less than 2.5 m (8 ft) above finished floor.
    b. Stub-ups to above suspended ceilings.

3. Exposed and Not Subject to Physical Damage: EMT.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: ERMC or IMC.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
7. Connection to recessed luminaires: FMC.

D. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.

1. ERMC and IMC: Provide threaded-type fittings unless otherwise indicated.

3.2 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
2. Type HDPE: Article 353 of NFPA 70 and NECA NEIS 111.
3. Type ERMC-S: Article 344 of NFPA 70 and NECA NEIS 101.
4. Type FMC-S: Article 348 of NFPA 70 and NECA NEIS 101.
5. Type FMT: Article 360 of NFPA 70 and NECA NEIS 101.
6. Type IMC: Article 342 of NFPA 70 and NECA NEIS 101.
7. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
8. Type PVC: Article 356 of NFPA 70 and NECA NEIS 111.
9. Expansion Fittings: NEMA FB 2.40.

10. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. General Requirements for Installation of Duct Raceways:

a. Complete duct raceway installation before starting conductor installation.
b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
c. Install no more than equivalent of three 90-degree bends in conduit run. Support within 12 inch of changes in direction.
d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
f. Support conduit within 12 inch of enclosures to which attached.
g. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.
h. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct 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 duct raceway enters a building or structure.
3) Conduit extending from interior to exterior of building.
4) Conduit extending into pressurized duct raceway 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.

i. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.
j. Do not install conduits within 2 inch of the bottom side of a metal deck roof.
k. Keep duct raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.
l. Cut conduit perpendicular to the length. For conduits trade size 2 and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
m. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.
n. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.

1) Termination fittings with shoulders do not require two locknuts.

o. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to trade size 1-1/4 and insulated throat metal bushings on trade size 1-1/2 and larger conduits terminated with locknuts..

2. Types ERMC and IMC:

a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.

3. Type ERMC-S-PVC:

a. Follow manufacturer's installation instructions for clamping, cutting, threading, bending, and assembly.
b. Provide PVC-coated sealing locknut for exposed male threads transitioning into female NPT threads that do not have sealing sleeves, including transitions from PVC couplings/female adapters to Type ERMC-S-PVC elbows in direct-burial applications. PVC-coated sealing locknuts must not be used in place of conduit hub. PVC-coated sealing locknut must cover exposed threads on Type ERMC-S-PVC duct raceway.
c. Coat field-cut threads on PVC-coated duct raceway with manufacturer-approved corrosion-preventing conductive compound prior to assembly.

4. Types FMC and LFMC:

a. Provide a maximum of 72 inch of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

5. Types PVC and HDPE:

a. Do not install Type PVC or Type HDPE conduit where ambient temperature exceeds **122 deg F**. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
b. Comply with manufacturer's published instructions for solvent welding and fittings.

6. Stub-ups to Above Recessed Ceilings:

a. Provide EMT, IMC, or ERMC for duct raceways.
b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

7. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:

a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG..

8. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.

a. ERMC-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
b. EMT: Provide compression, steel fittings. Comply with NEMA FB 2.10.
c. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

9. Expansion-Joint Fittings:

a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.
b. Install type and quantity of fittings that accommodate temperature change listed for the following locations:

1) Outdoor Locations Not Exposed to Direct Sunlight: **125 deg F** temperature change.
2) Outdoor Locations Exposed to Direct Sunlight: **155 deg F** temperature change.
3) Indoor Spaces Connected with Outdoors without Physical Separation: **125 deg F** temperature change.

c. 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.
d. Install expansion fittings at locations where conduits cross building or structure expansion joints.
e. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

10. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty **or firestopping**.
11. Identification: Provide labels for conduit assemblies, duct raceways, and associated electrical equipment.

a. Provide warning signs.

D. Interfaces with Other Work:

1. Coordinate installation of new products for with existing conditions.

2. Coordinate with Section 078413 "Penetration Firestopping" for installation of firestopping at penetrations of fire-rated floor and wall assemblies.
3. Coordinate with Section 260529 "Hangers and Supports for Electrical Systems" for installation of conduit hangers and supports.

3.3 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 PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533.13

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metallic outlet boxes, device boxes, rings, and covers.
2. Junction boxes and pull boxes.
3. Cover plates for device boxes.
4. Hoods for outlet boxes.

B. Related Requirements:

1. 018116Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.
2. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
3. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
4. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.

1.2 260573ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components 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.

2.2 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Source Quality Control:

B. UL QCIT - Metallic Outlet Boxes and Covers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Arlington Industries, Inc.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
h. Pass & Seymour; Legrand North America, LLC.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN QCIT; including UL 514A.

3. Standard Features:

a. Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
b. Material: Sheet steel Cast metal.
c. Sheet Metal Depth: Minimum 2.5 inch.
d. Cast-Metal Depth: Minimum 2.4 inch.

C. UL QCIT - Metallic Conduit Bodies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
e. Pass & Seymour; Legrand North America, LLC.
f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN QCIT; including UL 514A.

3. Standard Features: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.

D. UL QCIT - Metallic Device Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Appleton; Emerson Electric Co., Automation Solutions.
    b. Arlington Industries, Inc.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    g. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
    h. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. UL CCN QCIT; including UL 514A.

3. Standard Features:

    a. Box with provisions for mounting wiring device directly to box.
    b. Material: Sheet steel Cast metal.
    c. Sheet Metal Depth: minimum 2.5 inch.
    d. Cast-Metal Depth: minimum 2.4 inch.

E. UL QCIT - Metallic Extension Rings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Appleton; Emerson Electric Co., Automation Solutions.
    b. Cooper B-line; brand of Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
    f. Pass & Seymour; Legrand North America, LLC.
    g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. UL CCN QCIT; including UL 514A.

3. Standard Features: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

F. UL QCIT - Metallic Floor Boxes and Floor Box Covers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arlington Industries, Inc.
    b. FSR Inc.
    c. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    e. Leviton Manufacturing Co., Inc.
    f. Pass & Seymour; Legrand North America, LLC.
    g. Wiremold; Legrand North America, LLC.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. UL CCN QCIT; including UL 514A.

3. Standard Features: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

G. UL QCIT - Metallic Concrete Boxes and Covers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Crouse-Hinds; brand of Eaton, Electrical Sector.
    b. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    d. Wiremold; Legrand North America, LLC.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. UL CCN QCIT; including UL 514A.

3. Standard Features: Box intended for use in poured concrete.

2.3 JUNCTION BOXES AND PULL BOXES

A. UL BGUZ - Indoor Sheet Metal Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Cooper B-line; brand of Eaton, Electrical Sector.
    b. Hoffman; brand of nVent Electrical plc.
    c. Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN BGUZ; including UL 50 and UL 50E.

3. Standard Features:

a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
b. Degree of Protection: Type 2.

B. UL BGUZ - Indoor Cast-Metal Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Adalet.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN BGUZ; including UL 50 and UL 50E.

3. Standard Features:

a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
b. Degree of Protection: **Type 2**.

C. UL BGUZ - Outdoor Sheet Metal Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. FSR Inc.
d. Hoffman; brand of nVent Electrical plc.
e. Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

f. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
h. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN BGUZ; including UL 50 and UL 50E.

3. Standard Features:

a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
b. Degree of Protection: Type 3R.

D. UL BGUZ - Outdoor Cast-Metal Junction and Pull Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN BGUZ; including UL 50 and UL 50E.

3. Standard Features:

a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
b. Degree of Protection: Type 3R.

2.4 COVER PLATES FOR DEVICE BOXES

A. UL QCIT or QCMZ - Metallic Cover Plates for Device Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Leviton Manufacturing Co., Inc.
f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
g. Pass & Seymour; Legrand North America, LLC.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.

3. Standard Features:

a. Cover plate-Securing Screws: Metal with head color to match cover plate finish.
b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
c. Cover Plate Material: **0.032 inch thick, Type 302/304 non-magnetic stainless steel with brushed finish** or **Galvanized steel in unfinished spaces**.

2.5 HOODS FOR OUTLET BOXES

A. UL QCIT or QCMZ - Extra-Duty, While-in-Use Hoods for Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Arlington Industries, Inc.
d. Leviton Manufacturing Co., Inc.
e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.

3. Standard Features:

a. Mounts to box using fasteners different from wiring device.
b. Marked "Extra-Duty" in accordance with UL 514D.
c. Provides gray, weatherproof, "while-in-use" cover.

PART 3 - EXECUTION

3.1 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:

a. Type 3R unless otherwise indicated.
b. Locations Exposed to Hosedown: Type 4.
c. Locations Subject to Potential Flooding: Type 6P.
d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.
e. Locations in-Ground or Exposed to Corrosive Agents: Type 4X.
f. Locations in-Ground or Exposed to Corrosive Agents Where Mechanism Must Operate When Ice Covered: Type 3SX.

2. Indoors:

a. Type 1 unless otherwise indicated.
b. Damp or Dusty Locations: Type 12.
c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: Type 4.
f. Locations Exposed to Hosedown: Type 4.
g. Locations Exposed to Brief Submersion: Type 6.
h. Locations Exposed to Corrosive Agents: Type 4X.

C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:

1. Provide cast-metal boxes.
2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.2 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Communications Work: BICSI N1.

6. Life Safety and Means of Egress Work: NFPA 101.
7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
8. Work in Confined Spaces: NFPA 350.
9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
10. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
11. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
2. 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.
3. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.
4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
5. Locate boxes so that cover or plate will not span different building finishes.
6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
9. Set metal floor boxes level and flush with finished floor surface.
10. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
11. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
12. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:

    a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
    b. Provide gaskets for cover plates and covers.

3.3 CLEANING

A. Remove construction dust and debris from boxes before installing cover plates, covers, and hoods.

3.4 PROTECTION

A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260533.16

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EPEC raceways and fittings.
2. Type ERMC-S raceways, elbows, couplings, and nipples.
3. Type PVC raceways and fittings.
4. Fittings for conduit, tubing, and cable.
5. Electrically conductive corrosion-resistant compounds for threaded conduit.
6. Solvent cements.
7. Duct accessories.
8. Handholes and boxes for exterior underground wiring.
9. Utility structure accessories.
10. Duct sealing.

B. Related Requirements:

1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section. 260010
2. 260011**013100**Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
3. Section 260553 "Identification for Electrical Systems" specifies underground-line warning tape and concrete cable routing markers (warning planks).

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For concrete and steel used in precast concrete handholes, also include product certificates as required by ASTM C858.

B. Shop Drawings:

1. Electric Utility Duct Banks and Structures:

a. Include plans, elevations, sections, and details, including attachments to other Work.
b. Indicate locations of private property boundaries and utility easements.
c. Include information required for approval by electric utility and for obtaining public space utility work permits.

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, and methods and materials for waterproofing duct entry locations.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and other accessories.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

D. Sustainable design submittals.

1.3 INFORMATIONAL SUBMITTALS

A. Certificates:

1. For concrete and steel used in precast concrete handholes, as required by ASTM C858.

B. Manufacturers' Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. Source Quality-Control Submittals:

1. Source quality-control reports.

PART 2 - PRODUCTS

2.1 TYPE EPEC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651A and UL CCN EAZX.

B. Schedule 40 Electrical HDPE Underground Conduit (EPEC-40):

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. Dimensional Specifications: Schedule 40.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

C. Schedule 80 Electrical HDPE Underground Conduit (EPEC-80):

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. Dimensional Specifications: Schedule 80.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.2 TYPE ERMC-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6 and UL CCN DYIX.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Wheatland Tube; Zekelman Industries.

2. Exterior Coating: Zinc.
3. Options:

a. Interior Coating: Zinc with organic top coating.
b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
c. Colors: As indicated on Drawings.

2.3 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651 and UL CCN DZYR.

B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Calconduit; Atkore International.
c. JM Eagle.
d. NAPCO; Westlake Chemical Corp.
e. National Pipe and Plastic, Inc. (Oldcastle).

2. Dimensional Specifications: Schedule 40.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

C. Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Calconduit; Atkore International.
c. JM Eagle.
d. National Pipe and Plastic, Inc. (Oldcastle).

2. Dimensional Specifications: Schedule 80.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

2.4 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Metallic Fittings for Type ERMC, Type PVC, and Type EPEC Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Appleton; Emerson Electric Co., Automation Solutions.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Konkore Fittings; Atkore International.
    e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
    f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    g. Southwire Company, LLC.

2. General Characteristics: UL 514B and UL CCN DWTT.
3. Options:

    a. Material: Steel.
    b. Coupling Method: Compression coupling.
    c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
    d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.5 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL Subject 2419 and UL CCN FOIZ.

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. ABB, Electrification Business.

2.6 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL CCN DWTT.

2.7 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. ABB, Electrification Business.
    b. Allied Tube & Conduit; Atkore International.
    c. Cantex Inc.
    d. IPEX USA LLC.

2.8 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:

    a. ASTM C858 for design and manufacturing processes.
    b. SCTE 77.

B. Source Quality Control:

1. Precast Concrete Utility Structures: Test and inspect in accordance with ASTM C1037.
2. Polymer Concrete and Nonconcrete Handhole and Pull-Box Prototypes: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests must be for specified tier ratings of products supplied. Testing machine pressure gages must have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

    a. Tests of materials must be performed by independent testing agency.
    b. Strength tests of complete boxes and covers must be by independent testing agency or manufacturer. Qualified registered professional engineer must certify tests by manufacturer.

C. Precast Concrete Handholes and Boxes:

1. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover must form top of enclosure and must have load rating consistent with that of handhole or box.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Elmhurst-Chicago Stone Co.
    b. Oldcastle Infrastructure Inc.; CRH Americas.
    c. Riverton Concrete Products.
    d. Utility Concrete Products, LLC.

3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Frame and Cover:

a. Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
b. Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
c. Weatherproof steel frame, with concealed-hinge steel access door assembly; tamper-resistant, captive, cover-securing bolts; hold-open ratchet assembly; and recessed cover handle.
d. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
e. Cover Legend: Molded lettering, as indicated for each service.

5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

a. Extension must provide increased depth of **12 inch**.
b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

6. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at installation location with ground-water level at grade.
7. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus additional 12 inch vertically and horizontally to accommodate alignment variations.
8. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
9. Handholes **12 inch wide by 24 inch long** and larger must have inserts for cable racks and pulling-in irons installed before concrete is poured.

D. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover:

1. Description: Molded of sand, concrete, and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or combination.

2. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

a. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.
b. MacLean Highline.
c. NewBasis.
d. Oldcastle Infrastructure Inc.; CRH Americas.
e. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and installed location.

a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
b. Cover Legend: Molded lettering, as indicated for each service.

5. Conduit Entrance Provisions: Conduit-terminating fittings must mate with entering ducts for secure, fixed installation in enclosure wall.

6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
8. Handholes **12 inch wide by 24 inch long** and larger must have factory-installed inserts for cable racks and pulling-in irons.
9. Options:

    a. Color: **Gray**.

E. High-Density Polyethylene (HDPE) Boxes:

1. Description: Injection molded of HDPE or copolymer-polypropylene. Cover must be made of polymer concrete.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Nordic Fiberglass, Inc.
    b. Oldcastle Infrastructure Inc.; CRH Americas.
    c. PenCell Plastics; brand of Hubbell Utility Solutions; Hubbell Incorporated.
    d. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

    a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
    b. Cover Legend: Molded lettering, as indicated for each service.

5. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
6. Duct Entrance Provisions: Duct-terminating fittings must be installed perpendicular to box wall and mate with entering duct for secure, fixed installation in enclosure wall without putting stress on box wall or fitting.
7. Options:

    a. Color: **Gray**.

2.9 033000DUCT SEALING

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

1. ABB, Electrification Business.
2. American Polywater Corporation.
3. CommScope, Inc.

4. Gardner Bender.
5. Ideal Industries, Inc.
6. NSi Industries LLC.
7. TE Connectivity Ltd.

B. 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. Compound must be 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. Duct sealing compound must be removable without damaging ducts or cables.

C. Inflatable Duct-Sealing System: Wraparound inflatable bladder that seals ducts that are empty or containing conductors against air and water infiltration. System is suitable for use in steel, plastic, or concrete ducts and penetrations.

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 field. Notify Architect if there is 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 Architect.

3.2 SELECTION OF UNDERGROUND DUCTS

A. Duct for Electrical Feeders: **PVC-80, PVC-40, EPEC-40** or **EPEC-80**, **direct buried** unless otherwise indicated.

B. Duct for Electrical Branch Circuits: **PVC-80, PVC-40, EPEC-40** or **EPEC-80**, direct buried unless otherwise indicated.

C. Bored Underground Duct: **EPEC-40** or **EPEC-80** unless otherwise indicated.

3.3 SELECTION OF UNDERGROUND ENCLOSURES

A. Handholes and Boxes:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-10 structural load rating.

2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
3. Units in Sidewalk and Similar Applications with Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Cover design load must not exceed load rating of handhole or box.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Restore area immediately after backfilling is completed or after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

E. Cut and patch existing pavement in path of underground duct, duct bank, and underground structures in accordance with "Cutting and Patching" Article in Section 017300 "Execution."

3.5 INSTALLATION OF DUCTS AND DUCT BANKS

A. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA TCB 2 for installation of underground ducts and duct banks.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Where indicated on Drawings, install duct, spacers, and accessories into duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
2. Steel raceway, bends, and fittings in single duct run or duct bank must be of same type.
3. Slope: Pitch duct minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from high point between two manholes to drain in both directions.
4. Expansion and Deflection Fittings: Install expansion and deflection fitting in each duct in area of disturbed earth adjacent to manhole or handhole.
5. Install expansion fitting near center of straight line duct with calculated expansion of more than 3/4 inch.
6. Curves and Bends:

a. Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of **48 inch12.5 ft25 ft**, both horizontally and vertically, at other locations unless otherwise indicated.
b. Field bending must be in accordance with NFPA 70 minimum radii requirements, except bends over 45 degrees must be made with minimum radius of **48 inch**. Use only equipment specifically designed for material and size involved. Use PVC heating bender for bending PVC conduit.
c. Duct must have maximum of 180 degrees of bends between pull points.

7. Joints: Use solvent-cemented joints in nonmetallic duct and fittings and make watertight in accordance with manufacturer's published instructions. Stagger couplings so those of adjacent duct do not lie in same plane. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.

    a. Install insulated grounding bushings on steel raceway terminations that are less than 12 inch below grade or floor level and do not terminate in hubs.

8. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing duct will not be subject to environmental temperatures above 104 deg F. Where environmental temperatures are calculated to rise above 104 deg F, and anywhere duct crosses above underground steam line, install insulation blankets listed for direct burial to isolate duct bank from steam line to maintain maximum environmental temperature of 104 deg F.
9. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inch o.c. for 5 inch duct, and vary proportionately for other duct sizes.

    a. Begin change from regular spacing to end-bell spacing 10 ft from end bell, without reducing duct slope and without forming trap in line.
    b. Grout end bells into structure walls from both sides to provide watertight entrances.

10. Duct Terminators for Entrances to Cast-in-Place Manholes and Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inch o.c. for 4 inch duct, and vary proportionately for other duct sizes.

    a. Begin change from regular spacing to terminator spacing 10 ft from terminator, without reducing duct line slope and without forming trap in line.

11. Building Wall Penetrations: Make transition from underground duct to steel raceway at least 10 ft outside building wall, without reducing duct line slope away from building and without forming trap in line. Use fittings manufactured for transition to steel raceway type installed. Install steel raceway penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
12. 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.
13. Pulling Cord: Install 200 lbf test nylon cord in empty ducts.

14. 312000033000Direct-Buried Duct and Duct Bank:

a. 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 inch in nominal diameter.
b. Width: Excavate trench **3 inch** wider than duct on each side.
c. Depth: Install top of duct at least 36 inch below finished grade unless otherwise indicated.
d. Set elevation of top of duct bank below frost line.
e. Place minimum 3 inch of sand as bed for duct. Place sand to minimum of 6 inch above top level of duct.
f. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
g. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch 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.
h. Install duct with minimum of 3 inch between ducts for like services and 6 inch between power and communications duct.
i. 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 inch 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.

15. Underground-Line Warning Tape: Bury nonconducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inch above concrete-encased duct and duct banks. Align tape parallel to and within 3 inch of centerline of duct bank. Provide additional warning tape for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional tapes 12 inch apart, horizontally across width of ducts.
16. Ground ducts and duct banks in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 033000**071353071354**071113260526NSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Reference Standards:
1. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
2. Unless otherwise indicated, support units on level bed of crushed stone or gravel, graded from 1/2 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

3. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Install handholes and boxes with bottom below frost line, below grade.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
6. Field cut openings for duct in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
7. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour concrete ring encircling, and in contact with enclosure entry, and with top surface screeded to top of box cover frame. Bottom of ring must rest on compacted earth.

    a. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with troweled finish.
    b. Dimensions: **10 inch wide by 12 inch deep**.

8. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

B. Field tests and inspections must be witnessed by Architect.

C. 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 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."

D. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

E. Assemble and submit test and inspection reports.

END OF SECTION 260543

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Pourable sealants.

B. Related Requirements:

1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

A. Steel Wall Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, LLC.
b. CCI Piping Systems.
c. Flexicraft Industries.
d. GPT; a division of EnPRO Industries.
e. Specified Technologies Inc.

2. General Characteristics: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. PVC Pipe Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CCI Piping Systems.
b. GPT; a division of EnPRO Industries.
c. Metraflex Company (The).

2. General Characteristics: ASTM D1785, Schedule 40.

C. Round, Galvanized-Steel, Sheet Metal Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Benefast.
b. Specified Technologies Inc.

2. General Characteristics: Galvanized-steel sheet; thickness not less than 0.0239 inch; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, LLC.
2. American Polywater Corporation.
3. BWM Company.
4. CALPICO, Inc.
5. Flexicraft Industries.
6. GPT; a division of EnPRO Industries.
7. Metraflex Company (The).
8. Proco Products, Inc.
9. Roxtec Inc.

B. General Characteristics: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.

C. Options:

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Holdrite; a division of Reliance Worldwide Corporation.

B. General Characteristics: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Specified Technologies Inc.
2. W. R. Meadows, Inc.

B. General Characteristics: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Design Mix: 5000 psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.5 POURABLE SEALANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carlisle Syntec Systems.
2. GAF.
3. Johns Manville; a Berkshire Hathaway company.
4. Specified Technologies Inc.

B. Performance Criteria:

1. General Characteristics: Single-component, neutral-curing elastomeric sealants of grade indicated below.

a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. 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 space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide **1/4 inch** annular clear space between sleeve and raceway or cable, unless sleeve-seal system 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. Install sleeves for floor penetrations. Extend sleeves installed in floors **2 inch** above finished floor level. Install sleeves during erection of floors.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for wall assemblies.

C. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

D. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

E. Underground, Exterior-Wall and Floor Penetrations:

1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.
2. Install steel pipe sleeves. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Grout sleeve into wall or floor opening.

3.2 INSTALLATION OF RECTANGULAR SLEEVES AND SLEEVE SEALS

A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.

B. Install conduits and cable with no crossings within the sleeve.

C. Fill opening around conduits and cables with expanding foam without leaving voids.

D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.3 INSTALLATION OF SLEEVE-SEAL SYSTEMS

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

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Extruded insulating tubing.
3. Bands.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.

B. Related Requirements:

1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.260010

1.2 ACTION SUBMITTALS

A. Product data.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 LABELS

A. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN PGDQ2 for components; including UL 969.

B. UL PGDQ2 - Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Champion America.
c. HellermannTyton.
d. LEM Products Inc.
e. Panduit Corp.
f. emedco.

C. UL PGDQ2 - Self-Adhesive Wraparound Labels: Preprinted, 3 mil thick, polyester flexible label with acrylic pressure-sensitive adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brother International Corporation.
c. Grafoplast Wire Markers.
d. Ideal Industries, Inc.
e. LEM Products Inc.
f. Panduit Corp.
g. emedco.

2. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
3. Marker for Labels:

a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. UL PGDQ2 - Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brother International Corporation.
c. HellermannTyton.
d. Ideal Industries, Inc.
e. LEM Products Inc.
f. Panduit Corp.
g. emedco.

2. Minimum Nominal Size:

a. 1-1/2 by 6 inch for raceway and conductors.
b. 3-1/2 by 5 inch for equipment.
c. ½ inch high and complete circuit number for devices and components.
d. As required by authorities having jurisdiction.

2.2 BANDS

A. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services Inc.
d. Panduit Corp.

B. 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.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services Inc.
d. Panduit Corp.

2.3 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Champion America.
c. HellermannTyton.
d. Ideal Industries, Inc.
e. Panduit Corp.

B. 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.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services, Inc.
d. emedco.

C. 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.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. HellermannTyton.
b. LEM Products Inc.
c. Marking Services Inc.
d. Pipemarker.com; Brimar Industries, Inc.
e. Seton Identification Products; a Brady Corporation company.

D. Floor Marking Tape: 2 inch wide, 5 mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Seton Identification Products; a Brady Corporation company.

E. Underground-Line Warning Tape:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Ideal Industries, Inc.
c. LEM Products Inc.
d. Marking Services Inc.
e. Pipemarker.com; Brimar Industries, Inc.
f. Reef Industries, Inc.
g. Seton Identification Products; a Brady Corporation company.

2. Tape:

a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electricalutility 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.

3. 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".

4. Nonconducting Line-Warning Tape:

a. Pigmented polyolefin, bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
b. Width: 3 inch.
c. Thickness: 4 mil.
d. Weight: 18.5 lb/1000 sq. ft.
e. Tensile in accordance with ASTM D882: 30 lbf and 2500 psi.

5. Reinforced Nonconducting Line-Warning Tape:

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.

6. Detectable Line-Warning Tape:

a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
b. Width: 3 inch.
c. Overall Thickness: 5 mil.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft.
f. Tensile in accordance with ASTM D882: 70 lbf and 4600 psi.

7. Reinforced Detectable Line-Warning Tape:

a. Reinforced, detectable three-layer laminate, consisting of printed pigmented woven scrim, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright-colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
b. Width: 3 inch.
c. Overall Thickness: 8 mil.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 34 lb/1000 sq. ft.
f. Tensile in accordance with ASTM D882: 300 lbf and 12,500 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height must be **1 inch**.

2.4 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services Inc.
d. Seton Identification Products; a Brady Corporation company.
e. emedco.

2. Engraved legend.
3. 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 white letters on black background.
d. Self-adhesive.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.5 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. HellermannTyton.
2. Ideal Industries, Inc.
3. Marking Services Inc.
4. Panduit Corp.

B. Performance Criteria:

1. Regulatory Requirements: 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: UL CCN ZODZ; including UL 1565 or UL 62275.

C. UL ZODZ - UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. UL ZODZ - Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F in accordance with ASTM D638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

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 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:

1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.
2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ft above finished floor.

B. Pipe and Conduit Labeling: Comply with ASME A13.1 and IEEE C2.

C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

1. Color must be factory applied.
2. Colors for 208Y/120 V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.
d. Neutral: White.
e. Ground: Green.

3. Colors for 480Y/277 V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.
d. Neutral: Gray.
e. Ground: Green with yellow stripe.

D. Color-Coding Raceways, Cable Trays, Junction Boxes, and Conductors for Intrinsically-Safe Circuits: Light blue. When used to identify intrinsically-safe circuits, Article 504 of NFPA 70 requires that the color light blue not be used for any other purpose.

E. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.

F. 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. "POWER."
2. "UPS."
3. "COMMUNICATIONS."

G. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. 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. Handholes, and Pull and Junction Boxes, 1000 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify phase.

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.
2. Identify system voltage with black letters on orange field.

J. Accessible Raceways 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.
2. Identify system voltage with.

K. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use write-on tags with conductor or cable designation, origin, and destination.

L. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with conductor designation.

M. Conductors to Be Extended in Future: Attach write-on tags to conductors.

N. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

O. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate to be labeled with its individual, sequential designation, composed of the following, in the order listed:

1. Wiring closet designation.
2. Colon.
3. Faceplate number.

P. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in direction of access to live parts. Workspace must comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

Q. Equipment Identification Labels:

1. Black letters on white field.
2. Indoor Equipment: Laminated acrylic or melamine plastic sign.
3. Outdoor Equipment: Laminated acrylic or melamine sign.
4. Equipment to Be Labeled:

    a. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of self-adhesive, engraved, laminated acrylic or melamine label.
    b. Enclosures and electrical cabinets.
    c. Communications cabinets.
    d. Access doors and panels for concealed electrical items.
    e. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
    f. Enclosed switches.
    g. Enclosed circuit breakers.
    h. Enclosed controllers.
    i. Variable-speed controllers.
    j. Push-button stations.
    k. Contactors.
    l. Remote-controlled switches, dimmer modules, and control devices.
    m. Monitoring and control equipment.
    n. Computer room air conditioners.
    o. Fire-alarm and suppression equipment.
    p. Egress points.

3.3 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. 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.

C. Electrical Hazard Warnings:

1. Arc-Flash Hazard Warning: Self-adhesive labels. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash hazard warning labels.

2. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
3. OSHA Workspace Clearance Warning Legend: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."

D. 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. Controls with external control power connections.

E. Operating Instruction Signs: Self-adhesive labels.

3.4 INSTALLATION

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. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes typical for electrical equipment environments specified in Section 260011 "Facility Performance Requirements for Electrical."

C. 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).

D. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

E. 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.

F. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Verify identity of item before installing identification products.

H. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

I. Apply identification devices to surfaces that require finish after completing finish work.

J. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

K. 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.

L. 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.

M. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

N. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

O. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.

P. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.

Q. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.

R. 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.

S. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.

T. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.

U. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

V. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

W. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.

X. 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. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

Y. Metal Tags:

1. Place in location with high visibility and accessibility.
2. Secure using UV-stabilized plenum-rated cable ties.

Z. Nonmetallic Preprinted Tags:

1. Place in location with high visibility and accessibility.
2. Secure using UV-stabilized plenum-rated cable ties.

AA. Write-on Tags:

1. Place in location with high visibility and accessibility.
2. Secure using UV-stabilized plenum-rated cable ties.

BB. 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.

CC. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

END OF SECTION 260553

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. 260010Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.
2. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 ACTION 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 must be in digital form.

a. Short-circuit study input data, including completed computer program input data sheets.
b. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
c. Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.4 QUALITY ASSURANCE

A. Study 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. EasyPower; brand of Bentley Systems, Inc.
2. Power Analytics, Corporation.
3. SKM Systems Analysis, Inc.

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.

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. Low-Voltage Fault Report: 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.

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:

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. 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.

E. 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.

F. 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.

G. 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.

H. Include in report identification of protective device applied outside its capacity.

END OF SECTION 260573.13

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 260573.13 "Short-Circuit Studies" for fault-current studies.
2. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 ACTION 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. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
d. Revised one-line diagram, reflecting field investigation results and results of coordination study.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. EasyPower; brand of Bentley Systems, Inc.
2. Power Analytics, Corporation.
3. SKM Systems Analysis, Inc.

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.

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. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. 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 Architect'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:

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. 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.
3. Generator.

E. 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.

F. 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.

G. 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.

H. 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.

I. Generator Protection: Select protection according to manufacturer's instructions and to IEEE 242.

J. 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.

K. 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.

L. 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. Prepare motor-starting study report, noting light flicker for limits proposed by IEEE 141, and, 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. Make minor modifications to equipment as required to accomplish compliance with **short-circuit and** protective device coordination studies.

C. Testing and adjusting must be by qualifiedlow-voltage electrical testing and inspecting agency.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

END OF SECTION 260573.16

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. 260010Section 260573.13 "Short-Circuit Studies" for fault-current studies.
2. Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.

1.2 DEFINITIONS

A. p.u.: Per unit. The reference unit, established as a calculating convenience, for expressing all power system electrical parameters on a common reference base.

1.3 ACTION 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. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
c. Revised one-line diagram, reflecting field investigation results and results of arc-flash study.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.5 QUALITY ASSURANCE

A. Study 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 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. EasyPower; brand of Bentley Systems, Inc.
2. Power Analytics, Corporation.
3. SKM Systems Analysis, Inc.

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.

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 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 according to IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.
4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.

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 and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to Architect's attention.
2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.

3.4 LABELING

A. Apply one arc-flash label on front cover of each section of equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each 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. Low-voltage switchgear
2. Switchboards.
3. Panelboards.
4. Low voltage transformers.
5. Safety switches.
6. Control panels.
7. Pumps.
8. Chillers.
9. Boilers.
10. Air Handlers.
11. Motors.

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

PART 1 - PRODUCTS

1.1 ELECTRONIC TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. Eaton.
3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC.
8. nLight; Acuity Brands Lighting, Inc.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Accessories:

a. Cover Plate: 0.035-inch thick, satin-finished, Type 302 stainless steel.

b. Cover Plate: Material for Unfinished Spaces, galvanized steel.
c. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

1.2 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. Douglas Lighting Controls.
3. Eaton.
4. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
5. Intermatic, Inc.
6. Leviton Manufacturing Co., Inc.
7. Lithonia Lighting; Acuity Brands Lighting, Inc.
8. Lutron Electronics Co., Inc.
9. NSi Industries LLC.
10. Philips; Signify North America; Signify Holding.
11. Sensor Switch, Inc.
12. Square D; Schneider Electric USA.
13. WattStopper; Legrand North America, LLC.

14. nLight; Acuity Brands Lighting, Inc

B. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Dual technology.
3. Integrated power pack.
4. Hardwired connection to switch and BAS.
5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
6. Operation:
   a. Combination Sensor: Unless otherwise indicated, sensor must 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: 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.
10. Mounting:
    a. Sensor: Suitable for mounting in any position in a standard device box or 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. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/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 sq. ft. when mounted 48 inch above finished floor.

1.3 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. Eaton.
3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC.
8. nLight; Acuity Brands Lighting, Inc.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS using hardwired connection.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, 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, 1200 VA LED load at 277 V, and 800 W incandescent.

C. Wall-Switch Sensor Tag OS1:

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: Dual voltage - 120 and 277 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: Gray.

11. Accessories:

a. Cover Plate: 0.035-inch thick, satin-finished, Type 302 stainless steel.

b. Cover Plate: Material for Unfinished Spaces, galvanized steel.
c. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

1.4 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. ASCO Power Technologies.
3. Allen-Bradley/Rockwell Automation.
4. Eaton.
5. Leviton Manufacturing Co., Inc.
6. Square D; Schneider Electric USA.

B. Description: Electrically operated and mechanically held, combination-type lighting contactors with fusible switch, 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.

1.5 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 2 - EXECUTION

2.1 INSTALLATION OF SENSORS

A. 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.

B. 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 instructions.

2.2 INSTALLATION OF CONTACTORS

A. 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.

2.3 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

2.4 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.

2.5 FIELD QUALITY CONTROL

A. 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. Nonconforming Work:

1. Lighting control devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Prepare test and inspection reports.

D. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

2.6 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.

2.7 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for two years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.

    a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3. Upgrade Reports: Prepare written report after each update, documenting upgrades installed.

END OF SECTION 260923

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 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.260010

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

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.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Transformer working clearances, anchoring, torque values, and insulation-resistance testing.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. Eaton.
3. Hammond Power Solutions Inc.
4. Siemens Industry, Inc., Energy Management Division.
5. SolaHD; Emerson Electric Co.
6. Square D; Schneider Electric USA.

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.

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.

C. Coils: Continuous windings except for taps.

1. Coil Material: Aluminum.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Welded.

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.
   b. Outdoor: UL 50E, Type 3R.

E. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

F. 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.

G. 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.

H. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

2.4 IDENTIFICATION

A. Nameplates:
   1. 260553Self-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. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.

3.2 INSTALLATION

A. **260548**Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions 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.

B. Secure transformer to concrete base in accordance with manufacturer's published instructions.

C. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.

D. 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. 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.

B. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.

C. 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.

D. Assemble and submit test and inspection reports.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Power panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Disconnecting and overcurrent protective devices.

B. Related Requirements:
1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section. 260010

1.2 DEFINITIONS

A. GFEP: Ground-fault equipment protection.

B. VPR: Voltage protection rating.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Power panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Disconnecting and overcurrent protective devices.
4. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
5. 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. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for SPD as installed in panelboard.

7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include Internet link for electronic access to downloadable PDF of coordination curves.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Panelboard Schedules: For installation in panelboards.

B. Manufacturers' Published Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Recommended procedures for installing panelboards.
2. Recommended torque settings for bolted connections on panelboards.
3. Recommended temperature range for energizing panelboards.

C. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. 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.

1.7 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed panelboards perform in accordance with specified requirements and agrees to repair or replace components or products 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.

PART 2 - PRODUCTS

2.1 PANELBOARD COMMON REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing agency recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

D. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

   a. Indoor Dry and Clean Locations: UL 50E, Type 1.
   b. Outdoor Locations: UL 50E, Type 3R.

2. Height: 7 ft maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims must cover live parts and may have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims must cover live parts and may have no exposed hardware.

E. Incoming Mains:

1. Location: Convertible between top and bottom.

F. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

G. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type, with lug on neutral bar for each pole in panelboard.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type, with lug on bar for each pole in panelboard.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

H. Quality-Control Label: Panelboards must be labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards must have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

I. Future Devices: Panelboards must have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

J. Panelboard Short-Circuit Current Rating:
1. Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for 100 percent interrupting capacity.

K. Surge Suppression: Refer to Section 264313 “Surge Protective Devices for Low Voltage Electrical Power Circuits.”.

2.2 POWER PANELBOARDS

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. Listing Criteria: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inch high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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. Listing Criteria: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

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 flush latch with tumbler lock; keyed alike.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

a. RMS sensing.
b. Field-replaceable rating plug or electronic trip.
c. Digital display of settings, trip targets, and indicated metering displays.
d. Multi-button keypad to access programmable functions and monitored data.
e. Ten-event, trip-history log. Each trip event must be recorded with type, phase, and magnitude of fault that caused trip.
f. Integral test jack for connection to portable test set or laptop computer.
g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6 mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30 mA trip).
7. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.

b. Breaker handle indicates tripped status.
c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
g. 260913Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
h. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Panelboards: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NECA 407.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:
1. Mount top of trim 7.5 ft above finished floor unless otherwise indicated.
2. Mount panelboard cabinet plumb and rigid without distortion of box.
3. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
4. Install overcurrent protective devices and controllers not already factory installed.

a. Set field-adjustable, circuit-breaker trip ranges.

5. 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.
6. Install filler plates in unused spaces.
7. Stub four 1 inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in future. Stub four 1 inch empty conduits into raised floor space or below slab not on grade.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Panelboard Nameplates: Label each panelboard with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each branch circuit device in power panelboards with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

E. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles must be located on interior of panelboard door.

F. Breaker Labels: Faceplate must list current rating, UL and IEC certification standards, and AIC rating.

G. Circuit Directory:

1. Provide directory card inside panelboard door, mounted in transparent card holder.

    a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.

2. Provide computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

    a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.

3. Create directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Nonconforming Work:

1. Panelboards will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Collect, assemble, and submit test and inspection reports, including certified report that identifies panelboards included and that describes scanning results, with comparisons of two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262416

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cabinets and cutout boxes.
2. Miscellaneous enclosures.

B. Related Requirements:
1. 0181160181232600l0Section 078413 "Penetration Firestopping" specifies sealants for penetrations of rated walls and partitions referenced by this Section.
2. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
3. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding for RBBs referenced by this Section.
4. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.

1.2 270528**271100**ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Prepare and submit the following:

1. Shop Drawings for Custom Enclosures and Cabinets: Include plans, elevations, sections, and attachment details.
2. Shop Drawings for Racks or Frames:

a. Include plans, elevations, sections, details, and attachments to other work.
b. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
c. Include workspace requirements and access for cable connections.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components 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.

2.2 CABINETS AND CUTOUT BOXES

A. UL CYIV - Indoor Sheet Metal Cabinets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Cooper B-line; brand of Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hoffman; brand of nVent Electrical plc.
    e. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. Listing Criteria:

    a. UL CCN CYIV.
    b. Non-Environmental Characteristics: UL 50.
    c. Environmental Characteristics: UL 50E.

3. Standard Features:

    a. Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
    b. Degree of Protection: Type 1.

B. UL CYIV - Outdoor Sheet Metal Cabinets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Cooper B-line; brand of Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hoffman; brand of nVent Electrical plc.
    e. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. Listing Criteria:

    a. UL CCN CYIV.
    b. Non-Environmental Characteristics: UL 50.

c. Environmental Characteristics: UL 50E.

3. Standard Features:

a. Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
b. Degree of Protection: Type 3R.

2.3 MISCELLANEOUS ENCLOSURES

A. UL XCKT or NWIN - Indoor Sheet Metal Miscellaneous Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Hoffman; brand of nVent Electrical plc.
d. Square D; Schneider Electric USA.

2. Listing Criteria:

a. UL CCN XCKT; including UL 1773; or UL CCN NWIN, including UL 2416.
b. Non-Environmental Characteristics: UL 50.
c. Environmental Characteristics: UL 50E.

3. Standard Features:

a. Degree of Protection: Type 1.

B. UL XCKT or NWIN - Outdoor Sheet Metal Miscellaneous Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Square D; Schneider Electric USA.

2. Listing Criteria:

a. UL CCN XCKT; including UL 1773; or UL CCN NWIN, including UL 2416.
b. Non-Environmental Characteristics: UL 50.
c. Environmental Characteristics: UL 50E.

3. Standard Features:

a. Degree of Protection: Type 3R.

PART 3 - EXECUTION

3.1 SELECTION OF ELECTRICAL CABINETS AND ENCLOSURES

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of electrical cabinets and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:

a. Type 3R unless otherwise indicated.
b. Locations Exposed to Hosedown: Type 4.
c. Locations Subject to Potential Flooding: Type 6P.
d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.

2. Indoors:

a. Type 1 unless otherwise indicated.
b. Damp or Dusty Locations: Type 12.
c. Locations Exposed to Hosedown: Type 4.

3.2 INSTALLATION OF ELECTRICAL CABINETS AND ENCLOSURES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
4. Work in ITE Rooms: NFPA 75.
5. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
6. Cabinets and Cutout Boxes: Article 312 of NFPA 70.
7. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Mount cabinets and enclosures 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.
2. Do not install cabinets, enclosures, or fittings in contact with concrete or earth.
3. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
4. Identification: Provide labels for cabinets, enclosures, racks and associated electrical equipment.

a. Identify field-installed conductors, interconnecting wiring, and components.
b. Provide warning signs.
c. Label each cabinet, enclosure, and rack with engraved metal or laminated-plastic nameplate.

D. Interfaces with Other Work:

1. Firestop penetrations of rated walls and partitions.
2. Apply arc-flash hazard warning labels cabinets, enclosures, and racks.

E. Cleaning: Remove construction dust and debris from cabinets, enclosures, and racks.

F. Protection: Protect coatings and finishes of cabinets, enclosures, and racks from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.3 FIELD QUALITY CONTROL OF ELECTRICAL CABINETS AND ENCLOSURES

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.

C. Nonconforming Work:

1. Cabinet, enclosure, or rack will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

END OF SECTION 262716

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches, dimmer switches.
2. General-grade duplex straight-blade receptacles.
3. Receptacles with ground-fault protective devices.
4. Locking receptacles.

B. Related Requirements:
1. 260010260011**013100**Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.
2. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.

1.2 260936262726262726262726ACTION SUBMITTALS

A. Product Data:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade duplex straight-blade receptacles.
3. Receptacles with ground-fault protective devices.
4. Locking receptacles.

B. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Dimmers.
2. Duplex straight-blade receptacles.
3. Receptacles with GFCI device.
4. Locking receptacles.
5. Spring-driven commercial/industrial-use cord reels.

B. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

1.5 WARRANTY FOR DEVICES

A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: three years from date of Substantial Completion; full coverage for labor, materials, and equipment.

1.6 WARRANTY FOR CORD REELS

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to repair or replace assemblies 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.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that components of cord-reel power outlet assemblies perform 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. Initial Extended Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 GENERAL-USE SWITCHES AND DIMMER SWITCHES

A. Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. 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.

3. General Characteristics:

   a. Reference Standards: UL CCN WMUZ and UL 20.

4. Options:

   a. Device Color: Gray.
   b. Configuration:
      1) Extra-heavy-duty, 120-277 V, 20 A, single pole, three way and four way.

5. Accessories:

   a. Cover Plate: 0.035-inch thick, satin-finished, Type 302 stainless steel.

   b. Cover Plate: Material for Unfinished Spaces, galvanized steel.
   c. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Dimmer Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Lutron Electronics Co., Inc.
   e. Pass & Seymour; Legrand North America, LLC.

2. 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.

3. General Characteristics:

   a. Reference Standards: UL CCN EOYX and UL 1472 Type I dimmer.

4. Options:

   a. Device Color: Gray.
   b. Switch Style: Rocker.
   c. Dimming Control Style: Slide.

5. Accessories:

   a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.2 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour; Legrand North America, LLC.

2. 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.

3. General Characteristics:

   a. Reference Standards: UL CCN RTRT and UL 498.

4. Options:

   a. Device Color: Gray.
   b. Configuration:
      1) Heavy-duty, NEMA 5-20R.
      2) Heavy-duty, NEMA 6-20R.

5. Accessories:

   a. Cover Plate: 0.035-inch thick, satin-finished, Type 302 stainless steel.

   b. Cover Plate: Material for Unfinished Spaces, galvanized steel.
   c. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 RECEPTACLES WITH GROUND-FAULT PROTECTIVE DEVICES

A. General-Grade, Duplex Straight-Blade Receptacle with GFCI Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour; Legrand North America, LLC.

2. 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.

3. General Characteristics:

a. Reference Standards: UL CCN KCXX, UL 498, UL 943, UL 1699, and UL Subject 1699A.

4. Options:

a. Device Color: Gray
b. Configuration: Heavy-duty, NEMA 5-20R.

5. Accessories:

a. Cover Plate: 0.035-inch thick, satin-finished, Type 302 stainless steel.

b. Cover Plate: Material for Unfinished Spaces, galvanized steel.
c. Securing Screws for Cover Plate: Metal with head color matching wall plate finish.

B. General-Grade, Weather-Resistant, Duplex Straight-Blade Receptacle with GFCI Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour; Legrand North America, LLC.

2. 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.

3. General Characteristics:

a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.

4. Options:

a. Device Color: Gray.
b. Configuration: Heavy-duty, NEMA 5-20R.

5. Accessories:

a. Cover Plate: 0.035-inch thick, satin-finished, Type 302 stainless steel.

b. Cover Plate: Material for Unfinished Spaces, galvanized steel.
c. Securing Screws for Cover Plate: Metal with head color matching wall plate finish.

2.4 LOCKING RECEPTACLES

A. Locking Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.

2. 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.

3. General Characteristics:

   a. Reference Standards: UL CCN RTRT and UL 498.

4. Options:

   a. Device Color: Black with yellow voltage indication on face.
   b. Configuration: Refer to Drawings.

2.5 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

A. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 12 AWG:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements: 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.
3. General Characteristics:

   a. Reference Standards: UL CCN SBCV and UL 355.
   b. Spring take-up retraction mechanism.

4. Options:
   a. Refer to drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

B. Cord Reels:

1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SWITCHES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

3.3 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.

3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.

4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

3.4 INSTALLATION OF LOCKING RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

3.5 260553INSTALLATION OF CORD REELS AND FITTINGS

A. Comply with manufacturer's instructions.

3.6 262726FIELD QUALITY CONTROL OF SWITCHES

A. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' instructions.

B. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.7 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

3.8 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.9 FIELD QUALITY CONTROL OF CORD REELS AND FITTINGS

A. Tests and Inspections:

1. Perform tests and inspections indicated in manufacturer's instructions.

B. Nonconforming Work:

1. Components and assemblies will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.10 SYSTEM STARTUP FOR SWITCHES

A. Perform startup service.

1. Complete installation and startup checks for dimmer switches in accordance with manufacturer's instructions.

3.11 PROTECTION

A. Devices:

1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

B. Cord Reels and Fittings:

1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

2. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 262726

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Nonrenewable cartridge fuses.
2. Spare-fuse cabinets.

B. Related Requirements:
1. 018116018123260010260553Section 260573 "Power System Studies" specifies coordination studies, arc-flash hazard analysis, warning labels, and circuit-breaker trip ranges referenced by this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. 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 electronic format suitable for use in coordination software.
5. Coordination charts and tables and related data.

1.3 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 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 NONRENEWABLE CARTRIDGE FUSES

A. Class CC Nonrenewable Cartridge Fuse:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Bussmann, an Eaton business.
    b. Littelfuse, Inc.
    c. Mersen USA.
2. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-4 (Class CC).

3. Standard Features:

    a. NEMA FU 1, Class CC, 200 kA(sym) interrupt rating, current limiting, sizes up to 30 A, 600 V(ac), 12 s minimum time-delay at 200 percent, with rejection feature.

B. Class CD Nonrenewable Cartridge Fuse:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Bussmann; Eaton, Electrical Sector.
3. Littelfuse, Inc.
4. Mersen USA.
5. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-18 (Class CD).

6. Standard Features:

a. UL 248-18, Class CD, 200 kA(sym) interrupt rating, current limiting, sizes 31 to 60 A, 600 V(ac), 12 s minimum time-delay at 200 percent, with rejection feature.

C. Class J Nonrenewable Cartridge Fuse:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Bussmann; Eaton, Electrical Sector.
3. Littelfuse, Inc.
4. Mersen USA.
5. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-8 (Class J).

6. Standard Features:

a. NEMA FU 1, Class J, 200 kA(sym) interrupt rating, current limiting, sizes up to 600 A, 600 V(ac), non-time-delay, with rejection feature.

D. Class L Nonrenewable Cartridge Fuse:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Bussmann; Eaton, Electrical Sector.
3. Littelfuse, Inc.
4. Mersen USA.
5. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-10 (Class L).

6. Standard Features:

a. NEMA FU 1, Class L, 300 kA(sym) interrupt rating, current limiting, sizes 100 to 6000 A, 600 V(ac), non-time-delay, with rejection feature, with bolt-on terminals.

E. Class RK1 Nonrenewable Cartridge Fuse:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Bussmann; Eaton, Electrical Sector.
3. Littelfuse, Inc.

4. Mersen USA.
5. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-12 (Class R).

6. Standard Features:

    a. NEMA FU 1, Class RK1, 200 kA(sym) interrupt rating, current limiting, sizes up to 600 A, 600 V(ac), 8 to 10 s minimum time-delay at 500 percent, with rejection feature.

        1) Select ferrule terminals or knife blade terminals to match equipment where fuse is installed.

F. Class RK5 Nonrenewable Cartridge Fuse:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Bussmann; Eaton, Electrical Sector.
3. Littelfuse, Inc.
4. Mersen USA.
5. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

    a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-12 (Class R).

6. Standard Features:

    a. NEMA FU 1, Class RK5, 200 kA(sym) interrupt rating, current limiting, sizes up to 600 A, 600 V(ac), 8 to 10 s minimum time-delay at 500 percent, with rejection feature.

        1) Select ferrule terminals or knife blade terminals to match equipment where fuse is installed.

G. Class T Nonrenewable Cartridge Fuse:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Bussmann; Eaton, Electrical Sector.
    b. Littelfuse, Inc.
    c. Mersen USA.
2. Listing Criteria: Investigated, labeled, and marked by a qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Cartridge Fuses, Nonrenewable: UL CCN JDDZ, including UL 248-1 and UL 248-15 (Class T).

3. Standard Features:

a. NEMA FU 1, Class T, 200 kA(sym) interrupt rating, current limiting, sizes up to 1200 A, 600 V(ac), non-time-delay, with rejection feature.

1) Select ferrule terminals or knife blade terminals to match equipment where fuse is installed.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION OF FUSES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Work in Confined Spaces: NFPA 350.
5. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
6. Fuse Applications: NECA NEIS 420.
7. Work with Fuses in Motor Control Centers: NECA NEIS 402.

C. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

D. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

E. Install spare-fuse cabinet(s) in location indicated on the Drawings or as indicated in the field by Owner.

F. Interfaces with Other Work:

1. Identification: Provide labels for spare fuse cabinet.

a. Legend: "SPARE FUSES" in 1-1/2 inch high letters on exterior of door.

2. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with results of coordination study and arc-flash hazard analysis.

END OF SECTION 262813

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Fusible switches.
2. Nonfusible switches.
3. Enclosures.

B. Related Requirements:
1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.260010

1.2 DEFINITIONS

A. GFEP: Ground-fault circuit-interrupter for equipment protection.

B. GFLS: Ground-fault circuit-interrupter for life safety.

1.3 ACTION SUBMITTALS

A. Product Data:
1. 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.
2. Enclosure types and details for types other than UL 50E, Type 1.
3. Current and voltage ratings.
4. Short-circuit current ratings (interrupting and withstand, as appropriate).
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include 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 electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.
1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:
1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.6 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to repair or replace components or products 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.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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.

2.2 FUSIBLE SWITCHES

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. 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 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: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

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. Type HD, Heavy Duty, Three Pole, Single Throw, 240 and 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: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Service-Rated Switches: Labeled for use as service equipment.

2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, UL 50E, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: Enclosure must be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (UL 50E Type 1).

C. Conduit Entry: UL 50E Types 4, 4X, and 12 enclosures may not contain knockouts. UL 50E Types 7 and 9 enclosures must be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: Circuit-breaker operating handle must be externally operable with operating mechanism being integral part of box, not cover. Cover interlock mechanism must have externally operated override. Override may not permanently disable interlock mechanism, which must return to locked position once override is released. Tool used to override cover interlock mechanism must not be required to enter enclosure in order to override interlock.

E. Enclosures designated as UL 50E Type 4, 4X stainless steel, 12, or 12K must have dual cover interlock mechanism to prevent unintentional opening of enclosure cover when circuit breaker is ON and to prevent turning circuit breaker ON when enclosure cover is open.

F. UL 50E Type 7/9 enclosures must be furnished with breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 SELECTION OF ENCLOSURES

A. Indoor, Dry and Clean Locations: UL 50E, Type 1.

B. Outdoor Locations: UL 50E, Type 3R.

C. Other Wet or Damp, Indoor Locations: UL 50E, Type 4.

3.2 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Special Techniques:
1. 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.
2. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
3. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
4. Install fuses in fusible devices.

3.3 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.

3.4 FIELD QUALITY CONTROL

A. 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 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 following methods:

1) Use 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 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 must be in accordance with manufacturer's published data. In 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 Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

B. Nonconforming Work:
1. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Collect, assemble, and submit 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.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

260573END OF SECTION 262816

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Enclosed full-voltage magnetic motor controllers.
3. Enclosures.
4. Accessories.
5. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for 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. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed motor controllers perform in accordance with specified requirements and agrees to repair or replace components or products 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.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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 use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

2.2 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      a. ABB, Motion Business.
      b. Eaton.
      c. Siemens Industry, Inc., Energy Management Division.
      d. Square D; Schneider Electric USA.
   2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
   3. Configuration: Nonreversing.
   4. Surface mounting.
   5. Red pilot light.
   6. Additional Nameplates: FORWARD and REVERSE for reversing switches.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Eaton.
c. Rockwell Automation, Inc.
d. Siemens Industry, Inc., Energy Management Division.
e. Square D; Schneider Electric USA.

2. Configuration: Nonreversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Overload Relays: NEMA ICS 2, bimetallic class as schedule on Drawings.
5. Pilot Light: Red.

2.3 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

B. 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.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Overload Relays:

1. Thermal Overload Relays:

a. Inverse-time-current characteristic.
b. Class 10 tripping characteristic.

c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

2.4 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

2.5 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

a. Push Buttons: As indicated in the controller schedule.
b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable.

B. Motor protection relays shall be with solid-state sensing circuit and isolated output contacts for hardwired connections.

1. Phase-failure.
2. Phase-reversal, with bicolor LED to indicate normal and fault conditions. Automatic reset when phase reversal is corrected.
3. Under/overvoltage, operate when the circuit voltage reaches a preset value, and drop out when the operating voltage drops to a level below the preset value. Include adjustable time-delay setting.

2.6 IDENTIFICATION

A. Controller Nameplates: Baked enamel signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

C. 033000Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

E. 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.

F. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.2 260553FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Inspect contactors:

1) Verify mechanical operation.
2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

f. Motor-Running Protection:

1) Verify overload element rating is correct for its application.
2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with 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 according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests:
   a. Test motor protection devices according to manufacturer's published data.
   b. Test circuit breakers as follows:

      1) Operate the circuit breaker to ensure smooth operation.
      2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

   c. Perform operational tests by initiating control devices.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 SYSTEM FUNCTION TESTS

A. 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. 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.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain motor controllers.

END OF SECTION 262913.03

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Type 2 surge protective devices (SPDs).
2. Enclosures.

B. Related Requirements:
1. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.

1.2 262726DEFINITIONS

A. I_n: Nominal discharge current.

B. Voltage Protection Rating (VPR): A rating selected from UL 1449 list of preferred values assigned to each mode of protection.

1.3 ACTION 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 INFORMATIONAL SUBMITTALS

A. Sample warranty.

1.5 WARRANTY

A. Special Manufacturer Extended 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. Initial Extended Warranty Period: Five year(s) from date of Substantial Completion, for labor, materials, and equipment.
2. Follow-On Extended 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 2 SURGE PROTECTIVE DEVICES (SPDs)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. Advanced Protection Technologies Inc. (APT).
3. Eaton.
4. Schneider Electric USA, Inc.
5. Siemens Industry, Inc., Energy Management Division.

B. Source Limitations: Obtain devices from single source from single manufacturer.

C. General Characteristics:

1. Reference Standards: UL 1449, Type 2.
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. Peak Surge Current Rating: 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.
4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits must not exceed the following:

    a. Line to Neutral: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
    b. Line to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
    c. Neutral to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
    d. Line to Line: 2000 V for 480Y/277 V or 1200 V for 208Y/120 V.

5. SCCR: Equal or exceed 200 kA.
6. I_n Rating: 20 kA.

D. Options:

1. Include LED indicator lights for power and protection status.

2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V(ac) for remote monitoring of protection status.
4. Include surge counter.

2.2 ENCLOSURES

A. Indoor Enclosures: Type 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Architect.

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.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION 264313

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of LED luminaires:
   1. Downlight.
   2. Highbay, nonlinear.
   3. Recessed, linear.
   4. Strip light.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. 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.
   2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

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.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Product Certificates: For each type of luminaire.

C. Product test reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: 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.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

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.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Ambient Temperature: 41 to 104 deg F.

1. Relative Humidity: Zero to 95 percent.

B. Altitude: Sea level to 1000 feet.

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 lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. 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.

A. Refer to Light Fixture schedule for approved manufacturers and series.

B. Nominal Operating Voltage: Refer to light fixture schedule.

C. Lamp:

1. Minimum 250 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT: Refer to light fixture schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:

1. Refer to light fixture schedule for housing and heat sink.
2. Refer to light fixture schedule for finish.
3. Universal mounting bracket.
4. Integral junction box with conduit fittings.

E. 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.

F. Diffusers and Globes:

1. Refer to light fixture schedule.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. Recessed luminaires shall comply with NEMA LE 4.

2.4 HIGHBAY, NONLINEAR.

A. Refer to Light Fixture schedule for approved manufacturers and series.

B. Nominal Operating Voltage: Refer to lighting fixture schedule.

C. Lamp:

1. Minimum 10,000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. Refer to light fixture schedule to CRI and CCT.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.
   a.

7. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:

1. Refer to light fixture schedule for housing and heat sink.
2. Refer to light fixture schedule for finish.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers:

1. Refer to light fixture schedule.
2. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.5 RECESSED, LINEAR.

A. Refer to Light Fixture schedule for approved manufacturers and series.Nominal Operating Voltage: Refer to light fixture schedule.

B. Lamp:

1. Minimum 1,500 lm.
2. Minimum allowable efficacy of 85 lm/W.
3. CRI of minimum 80. CCT: Refer to light fixture schedule.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.

7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

C. Housings:

1. Refer to light fixture schedule for housing and heat sink.
2. Refer to light fixture schedule for finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:

1. Refer to light fixture schedule.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

F. Standards:

1. DLC certified.

2. ENERGY STAR certified.
3. RoHS compliant.
4. UL Listing: Listed for damp location.
5. NEMA LE 4.

2.6 STRIP LIGHT

A. Refer to Light Fixture schedule for approved manufacturers and series.

B. Nominal Operating Voltage: Refer to light fixture schedule.

C. Lamp:

1. Minimum 1000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. Refer to light fixture schedule for CRI and CCT.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to zero percent of maximum light output.
6. Internal driver.
   a.

7. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:

1. Refer to light fixture schedule for housing and heat sink.
2. Refer to light fixture schedule for finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping of luminaire without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. Refer to light fixture schedule.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.7 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. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:

1. 1. Manufacturer's standard grade.
2. 2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.8 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.9 LUMINAIRE SUPPORT

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.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

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 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. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 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.

260943END OF SECTION 265119

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency lighting.
2. Exit signs.
3. Materials.
4. Luminaire support components.

B. Related Requirements:
1. Section 260500 "Common Work Results For Electrical" for codes and standards, requirements for electrical installation, sleeve installations for electrical penetrations, and other Project requirements applicable to Work specified in this Section.

1.2 260010ACTION SUBMITTALS

A. Product Data:

1. For each type of emergency lighting unit, exit sign, and emergency lighting support.

a. Include data on features, accessories, and finishes.
b. Include physical description of unit and dimensions.
c. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
d. Include photometric data and adjustment factors based on laboratory tests by, or under supervision of, qualified luminaire photometric testing laboratory, for each luminaire type.

B. Shop Drawings:

1. For nonstandard or custom luminaires.

a. Include plans, elevations, sections, and mounting and attachment details.
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. Include diagrams for power, signal, and control wiring.

C. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of luminaire.

B. Sample Warranty: For manufacturer's warranty.

1.4 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: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 and UL 924, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with NFPA 101.

C. Comply with NEMA LE 4 for recessed luminaires.

D. Comply with UL 1598 for LED luminaires.

2.2 EMERGENCY LIGHTING

A. General Characteristics: Self-contained units.

B. Emergency Luminaire:

   1. Refer to light fixture schedule for manufacturer and series.
   2. Options:

      a. Operating at nominal voltage: Refer to light fixture schedule.
      b. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.
      c. UL 94 flame rating.
      d. UL 924 rated Generator Transfer Device for emergency lighting control.

2.3 EXIT SIGNS

A. General Characteristics: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Sign:
   1. Refer to light fixture schedule for manufacturer and series.Options:

      a. Operating at nominal voltage: Refer to light fixture schedule.
      b. Lamps for AC Operation:
         1) LEDs; 50,000 hours minimum rated lamp life.

2.4 MATERIALS

A. Metal Parts:

   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components must 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:
   1. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

   1. Refer to light fixture schedule.

E. Conduit: EMT, minimum metric designator 21 (trade size 3/4).

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 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. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to emergency power and retransfer to normal.

B. Nonconforming Work:

1. Luminaire will be considered defective if it does not pass operation tests and inspections.
2. Remove and replace defective units and retest.

C. Prepare test and inspection reports.

3.4 PROTECTION

A. Remove and replace luminaires and exit signs that are damaged or caused to be unfit for use by construction activities.

END OF SECTION 265213

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.

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 Submittals: For luminaire supports.

1. Include design calculations for luminaire supports.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated.

B. Product Certificates: For each type of the following:

1. Luminaire.

C. 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: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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. CRI of minimum 80. CCT: Refer to light fixture schedule.

E. L70 lamp life of 50,000 hours.

F. Lamps dimmable from 100 percent to 0 percent of maximum light output.

G. Nominal Operating Voltage: Refer to light fixture schedule.

H. In-line Fusing: Separate in-line fuse for each luminaire.

I. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

J. 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. Refer to light fixture schedule for manufacturer and series.
2. Luminaire Shape: Refer to light fixture schedule.
3. Mounting: Refer to light fixture schedule.
4. Luminaire-Mounting Height: Refer to light fixture schedule.
5. Distribution: Refer to light fixture schedule.

B. Canopy:
1. Refer to light fixture schedule for manufacturer and series.Shape: Refer to light fixture schdule.
2. Dimensions: Refer to light fixture schedule.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Refer to light fixture schedule. 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: Refer to light fixture schedule.

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 lamps 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 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 level, plumb, and square with finished grade unless otherwise indicated. 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. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533.13 "Conduits for Electrical Systems" for wiring connections and wiring methods.

3.2 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Install on concrete base with top as indicated on drawings. 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 260533.13 "Conduits 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. Photoelectric Control Operation: 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 265619

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PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This specification covers the furnishing and installation of materials for telecommunications systems structured cabling, video security systems, and complete and in operating condition as indicated on the drawings and/or as described herein.

1.2 REFERENCED STANDARDS

A. The following industry Standards are the basis for the structured cabling system described herein. The list is incorporated by this reference to them.

1. ANSI/TIA 568.0-D General Telecommunications Cabling for Customer Premises.
2. ANSI/TIA 568.1-D Commercial Building Telecommunications Cabling Standard.
3. ANSI/TIA 568-C.2 Balanced Twisted-Pair Telecommunications Cabling and Components Standards.
4. ANSI/TIA 568.3-D Optical Fiber Cabling Components Systems.
5. ANSI/TIA 569-E - Commercial Building Standard for Telecommunications Pathways and Spaces.
6. ANSI/TIA 569-E-1 Commercial Building Standard for Telecommunications Pathways and Spaces.
7. ANSI/TIA/EIA 606-C - The Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings. (Including Errata sheet for ANSI/TIA/EIA-606-B).
8. ANSI/TIA/EIA-606-A-1 Administrative Standard for Commercial Telecommunications Infrastructure. Addendum 1 – Administration of Equipment Rooms and Data Center Computer Rooms.
9. ANSI/TIA-607-C - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
10. ANSI/TIA-758-B Customer - Owned Outside Plant Telecommunications Infrastructure Standard.
11. TIA-526-7 - Measurement of Optical Power Loss of Installed Single-mode Fiber Cable Plant.
12. TIA-526-14-A - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant.
13. BICSI - Telecommunications Distribution Methods Manual (TDMM).
14. NEC - National Electric Code.
15. NFPA - National Fire Protection Association.
16. IEEE - Institute of Electrical and Electronics Engineers.
17. ISO - International Standards Organization.
18. UL - Underwriters Laboratories.

1.3 QUALITY ASSURANCE

A. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether or not specified or shown on the Drawings.

B. Contractor’s management team shall have demonstrated compliance with all applicable scopes of work. Contractor must demonstrate installation requirements as a Prime Contractor or Subcontractor on no less than three (3) projects of similar type, size and scope.

1. The Owner may, at its discretion, require the names, previous project list, and references for the Contractor’s management team and field personnel assigned to this project prior to the start of the work.
2. The Owner maintains the right to ask for replacement of management or field staff at any time during the project.

C. All cabling shall meet ANSI/TIA/EIA-568 and 569.

D. Termination and testing of the telecommunication cabling shall be performed by a qualified telecommunication installer with a minimum of 5 years' experience that can assure the installation and testing parameters are met.

1. Contractor and vendors shall have on staff a Building Industry Consulting Service International (BICSI) Registered Communications Distribution Designer (RCDD).
2. The RCDD shall approve construction design and upon completion of installation, certify compliance with the standards and installation practices as specified by this document.
3. The contractor must be registered with BICSI and 40% of the installation personnel must be BICSI registered telecommunications installers
4. RCDD must have five years' experience in this type of project and shall have completed no less than 3 successful projects of equivalent scope of work.
5. RCCD and BICSI certification for onsite Technician whom shall be the job Forman is required. Lead technician(s) shall have five years of experience in projects of similar scope.
6. The Contractor shall provide the services of a communication (computer) network company and provide equipment listed by Underwriters Laboratories, Inc. The computer network system contractor shall issue an equipment certification stating that the equipment and connected wiring and devices which form the specified system, together with installation have a Category 6A 20-year Application Assurance and 25-year product warranty on fiber optic cabling Installation, and are in compliance with the requirements established by EIT/TIA 568, 569, and BICSI Standards.
7. The telecommunications infrastructure shall be certified under the selected manufacturers warranty program. The contractors must show proof of certification with their respective bid proposals.

E. Prior to commencing the work of the project, the Contractor shall convene a meeting with the Project Manager, the Designer, and an IPS representative.

1. The meeting will cover Project Specifications, Addendum, Change orders, ER/TR layouts, labeling, and other project work, documents, and site conditions.
2. System testing procedures and requirements shall be confirmed at this time.
3. Test report forms and schedules shall be provided to the Owner for review.
4. Inspection milestones will be set and notifications scheduled.
5. Meeting minutes will be distributed and will include agreements, action items and responsible party(s) for this meeting and for future meetings when required.

F. Store materials and equipment in dry, environmentally controlled space. Do not install equipment and materials until spaces are enclosed, watertight, and dry. Protect equipment from dust and other airborne materials.

G. Contractor's regular job progress meetings with the Construction Manager and other Owner representatives shall include the Architect and the Technology Consultant as required.

H. Owner Inspection: The Owner will provide advice as requested.

1. The Owner may inspect the job as it progresses.
2. Prior to final acceptance of the work, the Contractor shall make arrangements with the appropriate authorized Owner representatives to inspect the construction areas, both to ensure satisfactory completion of the work and to ensure complete cleanup and restoration of areas affected by the work.
3. Temporary protection, coverings, and structures shall be removed at or before the time of inspection.
4. Examine areas and conditions with the Installer present for compliance with requirements and other conditions affecting the performance of telecommunication transmission media.

5. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the appropriate Owner representatives.

1.4 INTENT OF DRAWINGS AND SPECIFICATIONS

A. The telecommunications, audio visual, and security systems specified herein provide for information outlets and other low voltage signaling functions (such as for audio/video, energy management, and security systems) through twisted pair and fiber optic cable.

B. The systems shall provide acceptable outlets for any telecommunication device, which requires connection to other devices, networks or information services serving general facility needs.

1.5 DEFINITIONS

A. OUTSIDE PLANT: Transmission facilities used in the distribution of voice, data, or video from point where it leaves one building and enters another, including copper, coax, fiber optics, and microwave.

B. ENTRANCE CABLE: The outside plant cable(s) that enter the building from the campus outside plant communication distribution network.

C. MAIN BUILDING TELECOMMUNICATION EQUIPMENT ROOM (ER/MDF): The main telecommunication room located where the outside plant cabling and backbone cabling (risers) are interconnected. This room may also serve as a floor telecommunication equipment room (TR/IDF).

D. FLOOR TELECOMMUNICATION EQUIPMENT ROOM (TR/IDF): A telecommunication equipment room normally provided on every floor of the building. Floor equipment rooms must best spaced such that the length of any horizontal cable run shall not exceed 295 feet, wire length, termination to termination.

E. TELECOMMUNICATIONS ENCLOSURE (TE): This is specifically where wall-mounted equipment cabinets are provided in computer labs and where dedicated and secured ER/TR cannot be provided

F. BACKBONE CABLE (OSP): Cabling from outside or tunnel entrance of the Building to the Building Telecommunication Equipment Room (ER). Scope may include copper, coax, and fiber optics cabling.

G. RISER CABLE: Cabling from the Building Telecommunication Equipment Room (TR) to each Floor Telecommunication Equipment Room, including copper, coax, and fiber optics cabling.

H. STATION OUTLET BOX: The standard outlet box for telecommunications terminations shall be a double gang 4-11/16” square, 2-1/8” minimum depth box, with mud ring sizes as required.

I. TELECOMMUNICATIONS OUTLET: An assembly of interface ports for copper (data), copper (voice), coaxial, and various audio video connections; variations of arrangements are described elsewhere in this document.

J. UNSHEILDED TWISTED PAIR (UTP)

K. WIRELESS ACCESS POINT (AP)

L. PATHWAYS: Primary pathways are those supporting the cabling infrastructure through the corridors and chases to the secondary pathways. Secondary pathways are those supporting the cabling infrastructure from the primary pathway to telecommunications outlets.

M. BONDING: Refers to the electrical interconnection of conductive parts designed to maintain a common electrical potential. Bonding conductors must be of sufficient gauge to carry anticipated current due to power contact.

N. BONDING CONDUCTOR (BC): Typical bonding conductor installed from any telecommunications grounding bus bar (TMGB or TGB) to telecommunications equipment and/or raceway.

O. ELECTROMAGNETIC INTERFERENCE (EMI): The interference in signal transmission or reception resulting from the radiation of electrical or magnetic fields.

P. GROUNDING: Refers to the electrical connection of telecommunications hardware to an effective electrical ground. An effective electrical ground can be a power system Multi-Grounded Neutral (MGN), a grounded neutral of a secondary power system, or a specially constructed grounding system.

Q. MULTI-GROUNDED NEUTRAL (MGN): A utility power system where the neutral conductor is continuously present along with the phase conductors. The neutral conductor is connected to earth periodically along its path.

R. TELECOMMUNICATIONS BONDING CONDUCTOR (TBC): The bonding conductor installed from the building's grounding electrode system to the TMGB. This bonding conductor shall be sized the same as the TBB.

S. TELECOMMUNICATIONS BONDING BACKBONE (TBB): Continuous bonding conductor installed from the TMGB to the furthest telecommunications room. All TGB's shall attach to the TBB.

T. PRIMARY BONDING BUSBAR (PBB): The main telecommunications grounding bar located where the Outside Plant cables enter the telecommunications room.

U. SECONDARY BONDING BUSBAR (SBB): The telecommunications grounding bar located in every telecommunications room that does not contain the PBB.

1.6 SUBMITTALS

A. As part of this specification section, Contractor shall be responsible for providing the following submittals.

1. Manufacturer Product Data
2. As-Built Drawings
3. Cable Test Reports

B. Manufacturer Product Data - The Contractor shall provide manufacturers' catalog sheets, specifications, and installation instructions for all products to be installed within the scope of work. This is to verify that the submitted components comply with the Contract Documents. Submittals shall be formatted as follows.

1. Submit only products that appear in this section or that are required for a complete installation relating to the products in this section. Submission of products from multiple sections will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.
2. Product data for each product intended for installation shall be included once per submittal only. Duplicate copies of product data are not permitted.
3. Submittal shall include an index with page(s) listed in order of specification within corresponding section, with subsection number and generic name correlated to product submitted. Sheet index and/or product data sheets organized alphabetically, randomly or in any manner which does not match the specification order will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.
4. Following index sheet, include Manufacturer specification sheet stapled in order of properly organized index.

a. Where multiple products exist on a single sheet, Contractor shall clearly indicate, whether with highlight, arrow, PDF stamp, etc. the product intending to be used.
b. Failure to indicate specific product to be used will be cause for marking submittal Revise and Resubmit.

C. As-Built Drawings - The Contractor shall provide final documentation noting the actual installed conditions for this scope of work. This is to provide the Owner with accurate historical data of the project for future reference. As-Built Drawings shall be submitted during project close-out for inclusion in the O&M manual. Submittals shall be formatted as follows.

1. Submit one (1) PDF set of redlined Contract Documents or Contractor generated As-Built Drawings.
2. As-Built Drawings that utilize the Contract Documents as a base, shall be inclusive of all Published Addendums, ASIs, Accepted PCOs, PRs, SIs, etc. Changes made via RFI or Field Directive that were not published changes to the Contract Drawings shall be noted as such on the As-Builts with the noted RFI or FD #.
3. All text notes included on As-Builts shall be easily legible on PDF. Handwritten notes that are not legible shall be replaced with PDF text.
4. Include cable numbers as installed in the field. No marks are necessary if the Contract Document labels remained unchanged throughout construction. If deviations from the Contract Document labeling exist, Contractor shall note, legibly, the actual installed label(s).
5. Include final cable routes for all distribution paths installed in the field. This includes any deviations from the Contract Documents for Main Distribution pathways and any and all supplemental pathways installed by the Contractor. Information shall include the height and size of all pathways.
6. Include any deviations from the telecom rack elevations shown in the Contract Documents.
7. Include any deviations from published telecom schedules.

D. Cable Test Reports – The Contractor shall provide cable test reports that meet the requirements outlined in each applicable section. Cable Test Reports shall be submitted concurrently with As-Built Drawings.

1. Submit one (1) set of PDF test reports exported from cable testing software.
2. Quantity of cable test reports shall equal the total number of cables noted in the As-Built drawings.
3. All test results shall show a firm “PASS”.

E. OPERATION AND MAINTENANCE DATA:

1. Operation Data:

a. Prior to final project closeout and completion, contractor shall be required to submit operation data to the design team to turn over to the owner. At a minimum, the operations data shall include manufacturer’s installation and operating instructions.

2. Maintenance Data:
a. Prior to final project closeout and completion, contractor shall be required to submit maintenance data to the design team to turn over to the owner. At a minimum, the maintenance data shall include servicing requirements, inspection data, preventative maintenance schedule, exploded assembly views, replacement part numbers and availability, location and contact numbers of service depot.

1.7 RELATED SECTIONS

A. The following sections are related:

1. 27 05 26 – Grounding and Bonding for Communications Systems

2. 27 05 28 – Pathways for Communications Systems
3. 27 05 43 - Underground Ducts And Raceways for Communications Systems
4. 27 05 53 – Identification for Communications Systems
5. 27 11 00 – Communications Equipment Room Fittings
6. 27 11 16 – Communications Cabinets, Racks, Frames and Enclosures
7. 27 11 19 – Communications Termination Blocks and Patch Panels
8. 27 14 23 – Communications Optical Fiber Backbone Cabling
9. 27 15 00.23 – Audio Video Communications Horizontal Cabling
10. 27 15 13 – Communications Copper Horizontal Cabling
11. 27 15 43 – Communications Faceplates and Connectors
12. 27 41 16 - Integrated Audio Video Systems and Equipment
13. 27 51 23 - Central Sound and Paging System
14. 28 13 00 – Electronic Access Control
15. 28 23 00 – Video Security System

PART 2 - PRODUCTS

2.1 PRODUCT STANDARDS

A. All products to be installed for this project shall be new.

PART 3 - EXECUTION

3.1 TELECOMMUNICATIONS INSTALLATION

A. Installation procedures shall be in accordance with industry acceptable practices, product manufacturers' recommendations, Federal, State and Local codes and standards, and shall include demolition and removal of materials as required to support the work.

B. This section includes tools, materials, equipment, and labor necessary to complete a turnkey installation, including but not limited to the following items, which will be supplied by the Contractor unless otherwise noted by the Owner:

1. Cable trays, hangers, and mounting hardware
2. Conduit
3. Connecting blocks
4. Cross connect cable
5. Cross connect rings or spools
6. Equipment racks, mounting hardware and wire management
7. Labels for cables and receptacles
8. Modular station receptacles
9. Mounting brackets
10. Painted fire retardant plywood backboards
11. Riser and Backbone cable
12. Station blocks
13. Station cables
14. Velcro tie wraps, bushings, and miscellaneous

3.2 DELIVERY, STORAGE AND HANDLING

A. Deliver wire and cable properly packaged in factory-fabricated type containers or wound on NEMA-specified type wire and cable reels.

B. Store wire and cable in clean dry space in original containers, following manufacturers' storage guidelines. Protect products from weather, damaging fumes, construction debris and traffic.

C. Handle wire and cable carefully to avoid abrading, puncturing, kinking, and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance and characteristic impedance integrity of transmission media are maintained.

3.3 SEQUENCING AND SCHEDULING

A. Contractors must not interfere with academics. Normal work hours may be worked when school is not in session. During the school year, the contractor may not start work until after classes have been dismissed. Coordinate hours and building floor sequencing with Construction Manager and Owner’s Representative.

B. Coordinate with installation of wires/cables, electrical boxes and fittings, cable trays, and raceways.

C. Sequence installation of optical fiber cabling systems with other work to minimize possibility of damage during construction.

3.4 TECHNOLOGY PROCEDURE FOR UPS AND NETWORK SWITCHES

A. Owner shall furnish all Ethernet network switches, wireless access points, and UPS units.

B. Owner shall install all network switches as shown on the contract drawings. Network switches specifically required for audio visual control or systems shall be furnished and installed by the Contractor as required.

C. Contractor shall install all wireless access point locations as indicated on the contract drawings. Contractor shall install all Owner furnished patch cords for all wireless access point locations.

D. Owner shall install all UPS units serving each Telecommunications Room as indicated by the contract drawings. Coordinate with the owner for final UPS NEMA plug configuration prior to installation.

3.5 GENERAL INSTALLATION

A. No cable shall be installed in any facilities other than those intended for that use.

1. Gas pipe and water pipes must not be used for conduit under any circumstances.

B. Install telecommunication transmission media as indicated, in accordance with manufacturers’ written instructions, in compliance with applicable requirements of the NEC, and in accordance with recognized industry practices.

C. CMP (Plenum) type cable will be used for all telecommunications cables unless specifically noted otherwise.

D. Coordinate transmission media installation work as necessary to properly interface installation of media with other work.

E. Do not install compressed, kinked, scored, deformed, or abraded cable, or allow such damage to occur.

1. Damaged materials shall be removed from the job site immediately.

F. Use extreme care in handling, fishing, and pulling-in transmission media to avoid damage to conductors, shielding and jacketing/cladding.

1. Use pulling means including fish tape, cable, rope, and basket weave wire/cable grips, which will not damage media or raceway.
2. If power equipment is used to pull cable, the pull speed must not exceed 30 meters per minute.
3. Use water-based lubricant approved by the cable manufacturer to ensure manufacturers pulling tensions are not exceeded.

    a. Compound used must not deteriorate conductor or insulation.

4. Cable bending radii must not be exceeded.
5. Pulling methods must not cause cable to twist.
6. Cables pulled through pull boxes shall be hand assisted to prevent the cable from being crushed, kinked, or scraped.
7. Provide and install a nylon pull cord in all telecommunication conduits simultaneously with the pull-in of cable to facilitate future cable installations.
8. Pull conductors simultaneously where more than one is being installed in same raceway.
9. Splices in building media runs are NOT permitted.

    a. Building wiring must be continuous and undamaged from outlet to connecting block or connecting block to connecting block.

10. Terminations shall be made with manufacturers' stated tools and in accordance with manufacturers' instructions and guidelines.
11. Tighten connectors and terminals, including screws and bolts, in accordance with manufacturers' published torque tightening values. Where manufacturers torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque specified in UL Standard.
12. When necessary, within ER/TRs, horizontal station cables shall be secured with Velcro tie wraps. Both fiber and copper entrance and riser cable shall be secured with standard tie wraps. Observe the manufacturers' recommendations for distances between tie wraps and tightening tension from tie wraps and as specified in ANSI/TIA/EIA-568.

    a. Outside of ER/TRs horizontal cabling, entrance cables, and riser cables must be installed within industry standard pathways, such as cable tray, J hooks, and conduit.

13. Cables shall be permanently identified at each end with an industry approved label.
14. All wall penetrations for telecommunications cabling must be sleeved, with bushings at each end, and firestopped with removable/reusable material which has a minimum 2 hour rating, or in accordance with other architectural details, unless otherwise noted.

    a. Cables must not be installed through unsleeved holes drilled through walls.
    b. Comply with TIA/EIA 569 on Firestopping.
    c. Comply with UL1479 or ASTM E814, and label with the UL1479 or ASTM E814 reference number.

G. During construction, all existing equipment and racks that will remain on site during construction must be protected. An owner's representative must approve the temporary enclosure or conditions prior to the beginning of construction.

3.6 TESTING AND DOCUMENTATION

A. General

1. Acceptance testing shall be completed, and documentation provided to the Owner as soon as possible in order to permit the installation of networking equipment necessary to bring the building online for security and equipment monitoring systems.

2. Contractor shall complete all its own testing of all copper and optical fiber cabling. The owner will provide its own independent third party testing upon the completion of each phase. Upon the completion of the independent testing the owner will notify the contractor of the results and provide a notice to proceed. If any cabling does not pass testing and certification the contractor must provide all labor and material to correct the invalid cabling.

B. Testing

1. Acceptance testing by the Owner shall not occur until all work in each building area is completed, including but not limited to mounting and installation and termination of riser cables, backboards, terminating boxes and cabinets, grounding blocks, station wires, cameras, NVR, licenses or any other work necessary for the completion of the installation.
2. The Owner shall have the right to schedule acceptance testing at its convenience.
3. A representative of the Owner, and at the option of the Owner, shall be present during testing.
4. Such acceptance testing shall in no way reduce the Contractors' obligations regarding restoration, cleanup, or warranty.
5. Contractor shall perform tests necessary prior to acceptance testing to ensure that the installed cables will pass acceptance testing performed in conjunction with Owner representatives.
6. Contractor shall be responsible for performing, tracking, and recording the results of tests.
7. Contractor shall be responsible for providing equipment and materials necessary for as long a period of time as necessary to complete testing to the satisfaction of the Owner.
8. Test record forms shall be agreed to by the Owner prior to the commencement of acceptance testing.

C. Documentation

1. Provide record plant documentation, including jack type (telecommunications outlet), jack location, circuit length, fiber riser cable lengths, and any other information deemed to be useful.
2. The documentation format(s) will be agreed upon between the Owner and the Contractor.

    a. Provide all documentation in electronic format.
    b. If it is agreed to use proprietary software to provide testing results, the Contractor will be required to furnish licensed system software to run it unless the Owner already has a licensed version of the Contractor’s software.

3.7 AS-BUILT/RECORD DRAWINGS

A. Provide updated drawings of telecommunications systems in Autodesk CAD (.DWG) and PDF (.PDF) format.

B. As a minimum, the data provided must include the following elements, where applicable:

1. Outside Plant

    a. Cable Routing.
    b. Backbone cable, pair(count), strand, locations, and final cable lengths.
    c. Handhole and Manholes
    d. For each change reflected on the Record Drawings, the Change Order Request number shall be shown.

2. Inside Plant

    a. Cable Routing.
    b. Riser cable, pair (count), locations, and final cable lengths.

c. Supporting Structures.
d. Terminal locations and IDs.
e. Telecommunications Room and terminal details.
f. Conduit routing, installation heights and section lengths.
g. Pull box locations, installation heights and sizes.
h. Telecommunications Outlet locations, label IDs, types, and serving ER/TR.
i. For each change reflected on the Record Drawings, the Change Order Request number shall be shown.

3.8 WARRANTY

A. The warranty on labor and material installed by the Contractor shall be in effect for one (1) year from the date of acceptance of the work unless otherwise noted.

B. Contractor shall repair, adjust, and/or replace, whichever Indianapolis Public School District determines to be in its best interests, any defective equipment, materials, or workmanship, as well as such parts of the work damaged or destroyed by such defect, during the warranty period, at the Contractor's sole cost and expense.

C. In the event that any of the equipment specified, supplied, and/or installed as part of the work should fail to produce capacities or meet design specification as published or warranted by the manufacturer of the equipment involved or as specified in this document, the Contractor shall, in conjunction with the equipment manufacturer, remove and replace such equipment with equipment that will meet requirements without additional cost to the Owner.

D. In the event that the Contractor does not affect repair within seven (7) days from the date of notification of such defect, the Owner may secure repair services from other sources and charge the Contractor for such costs without voiding the warranty.

E. Guarantees of material, equipment, and workmanship running in favor of the Contractor shall be transferred and assigned to the Owner on completion of the work and acceptance of said work by the Owner.

END OF SECTION 270500

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of grounding and bonding infrastructure and includes the following:

1. Grounding Busbars
2. Bonding Connections

B. Related Sections include the following:

1. 270528 – Pathways for Communications Systems
2. 270553 – Identification for Communications Systems
3. 271100 – Communications Equipment Room Fittings
4. 271116 – Communications Cabinets, Racks, Frames and Enclosures
5. 274116 – Integrated Audio Video Systems and Equipment

1.2 QUALITY ASSURANCE

A. All 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 approval of the Owner. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

1.3 SUBMITTALS

A. Contractor shall provide all submittals according to Section 27 05 00.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 WALL MOUNTED BUSBARS

A. Secondary Busbar (SBB)

1. SBB shall be constructed of 1/4” (6.4 mm) thick solid copper bar.
2. The busbar shall be 2” (50.8 mm) high and 12” (304.8 mm) long and shall have 9 attachment points (one row) for two-hole grounding lugs.

3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI/TIA – 607-C and shall accept 6 lugs with 5/8” (15.9 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" (101.6 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell
    d. Panduit
    e. Or Equal

2.3 TELECOMMUNICATIONS BONDING BACKBONE (TBB)

A. Contractor shall provide a conductor that interconnects the Primary Bonding Busbar (PBB) in the ER/MDF to Secondary Bonding Busbars (SBB) in the TRs/IDFs.

B. The intended function of a TBB is to reduce or equalize potential differences between telecommunications systems; while the TBB will carry some current under ac power ground fault conditions, it is not intended to provide the only ground fault return path.

C. The TBB shall be constructed with copper ground wire solid or stranded, insulated or uninsulated as approved by the Owner, and sized according to length, as detailed in ANSI/TIA – 607-C, shown below:

WIRE LENGTH	WIRE SIZE (AWG)
<4 m / < 13 ft	6
4-6 m / 14-20 ft	4
6-8 m / 21-26 ft	3
8-10 m / 27-33 ft	2
10-13 m / 34-41 ft	1
13-16 m / 42-52 ft	1/0
16-20 m / 53-66 ft	2/0
20m – 26m / 67ft-84ft	3/0
26m – 32m / 85ft-105ft	4/0
32m – 38m / 106ft-125ft	250 kcmil
38m – 46m / 126ft-150ft	300 kcmil
46m – 53m / 151ft-175ft	350 kcmil
53m – 76m / 176ft-250ft	500 kcmil
76m – 91m / 251ft-300ft	600 kcmil
Greater than 91m / 301ft	750 kcmil

2.4 RACK MOUNT BUSBARS

A. Vertical Rack Busbar

1. Vertical rack-mount busbar shall be constructed of 1/4” (6.4 mm) thick by 5/8" (15.9 mm) high hard-drawn electrolytic tough pitch 110 alloy copper bar.
2. Bar shall be minimum of 36” (914.4 mm) long for mounting on relay racks or in cabinets.

3. Bar shall have eight 6-32 tapped ground mounting holes on 1” (25.4 mm) intervals and four 0.281” (7.1 mm) holes for the attachment of two-hole grounding lugs.
4. Each bar shall include a copper splice bar of the same material (to transition between adjoining racks) and two each 12-24 x 3/4” copper- plated steel screws and flat washers for attachment to the rack or cabinet.
5. Bar shall be UL Listed as grounding and bonding equipment.
6. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell
    d. Panduit
    e. Or Equal

2.5 BONDING CONDUCTORS

A. All grounding and bonding conductors shall be copper and may be insulated. When conductors are insulated, they shall be listed for the application. The minimum bonding conductor shall be No. 6 AWG.

B. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell
    d. Panduit
    e. Or Equal

2.6 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" (15.9 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. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell
    d. Panduit
    e. Or Equal

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.
4. Compression lugs shall be UL Listed as wire connectors.
5. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell
    d. Panduit
    e. Or Equal

C. Antioxidant Joint Compound

1. Oxide inhibiting joint compound for copper-to-copper, aluminum-to- aluminum or aluminum-to-copper connections.

2. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell
    d. Panduit
    e. Or Equal

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; installation requires a hydraulic crimping tool.
3. Compression taps shall be sized to fit specific size conductors, sizes #6 AWG to 4/0.
4. Compression taps shall be UL Listed.
5. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell
    d. Panduit
    e. Or Equal

E. HTAP Compression Kits

1. HTAP compression taps shall be manufactured from copper alloy.
2. Compression tap connectors shall wrap around two conductors forming an irreversible splice; installation requires a hydraulic crimping tool.
3. Compression taps shall be sized to fit specific size conductors, sizes #6 AWG to 4/0.
4. Shall include the installation of a manufacturer compliant cover.
5. Compression tap kits shall be UL Listed.
6. Acceptable Manufacturers:

    a. Cooper B-Line
    b. Chatsworth Products, Inc. (CPI)
    c. Hubbell

d. Panduit
e. Or Equal

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" (3/4" to 6.63" in diameter), as stated below.
4. Pipe clamp shall be UL Listed as grounding and bonding equipment.
5. Acceptable Manufacturers:

a. Cooper B-Line
b. Chatsworth Products, Inc. (CPI)
c. Hubbell
d. Panduit
e. Or Equal

G. Equipment Ground Jumper Kit

1. Kit includes one 24” long 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 1/2 ounce 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 spaced 1/2" to 5/8" apart that accept 1/4" screws.
4. Jumper will be made with UL Listed components.
5. Acceptable Manufacturers:

a. Cooper B-Line
b. Chatsworth Products, Inc. (CPI)
c. Hubbell
d. Panduit
e. Or Equal

PART 3 - EXECUTION

3.1 GENERAL

A. Bond metallic equipment racks, conduits, cable tray, and ladder racks to the ground bar.

B. All connectors and clamps shall be mechanical type made of silicon bronze.

C. Terminals shall be solderless compression type, copper long-barrel NEMA two bolt.

D. Bond the shield of shielded cable to the ground bar in telecommunications rooms and spaces.

E. Provide #6 AWG grounding conductor from the busbar to the electrical system equipment ground.

F. Grounding wire shall be appropriately bonded to the TMGB/PBB or TGB/SBB.

3.2 INSTALLATION

A. Wall Mount Busbars

1. Locate grounding bus bars to minimize ground wire lengths; location shall be as shown on the contract drawings and coordinated with the Owners representative and Technology Consultant.
2. Attach busbars to the wall with appropriate hardware according to the manufacturer's installation instructions.
3. Conductor connections to the PBB or SBB shall be made with two-hole bolt-on compression lugs sized to fit the busbar and the conductors.
4. 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.
5. The wall mounted busbar in each TR shall be bonded at minimum to the following:

    a. Building Steel, (minimum of No. 2 AWG insulated copper bonding conductor). CAD weld bonding conductors to Building Steel.
    b. Local Service Panel Ground (minimum No. 6 AWG insulated copper bonding conductor).
    c. Associated Telecommunications Cable Tray(s) (continuous No. 6 AWG bare copper bonding conductor connecting all Cable Tray sections.
    d. Telecommunications Conduits(s) entering TR (minimum No. 6 AWG insulated bonding conductor).

6. As a minimum, the Technology Contractor shall bond the following devices to the associated PBB and SBB using a minimum No. 6 AWG insulated copper bonding conductor using compression style lugs:

    a. Telecommunications Panel Board.
    b. Alternating Current Equipment Ground Bus (ACEG), if equipped, or its enclosure.
    c. Building Structural Steel, if exposed.
    d. Antenna Cable Shields.
    e. Backbone Cable Shields.
    f. CATV Equipment.
    g. Coupled Bonding Conductors (CBCs).
    h. Equipment Racks and Cabinets.
    i. Lightning and Surge Protectors.
    j. PABX Equipment.
    k. Raised Floors.
    l. Telecommunication and Fiber Cable Shields.
    m. Telecommunications Devices.
    n. TR Cable Ladder and Tray.

7. Label all SBB and the PBB with the following:

WARNING!!!

IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED
PLEASE CALL MAINTENANCE SERVICES AND ASK FOR THE ELECTRICIAN

B. 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 PBB or SBB with appropriately sized hardware and minimum No. 6 AWG conductor.

C. Ground Terminal Block

1. Every rack and cabinet shall be bonded to the PBB or SBB.
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.

D. Pipe Clamp

1. Bond metal pipes located inside the ER or TR with a minimum #6 AWG conductor to the PBB or SBB 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.

E. Equipment Ground Jumper Kit

1. Bond equipment to the horizontal rack mount busbar or ground bar using a 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 ground bar to help prevent corrosion at the bond.

3.3 INSTALLATION OF BONDING CONDUCTORS

A. Shall be routed so as to minimize bends and length.

B. Shall be a minimum of #6 AWG.

C. Bonding Conductors shall maintain a horizontal or downward path to the PBB or SBB. No bend shall form an included angle of more than 90 degrees or have a radius of less than 6".

D. Use appropriate HTAP kit or C-type compression tap to bond the TBB to the PBB or SBB.

END OF SECTION 270526

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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes minimum requirements for the following:

1. Interior Horizontal Cabling Communication Pathways.

B. Minimum requirements and installation methods for the following pathways:

1. Conduit
2. Floorboxes
3. Surface Mounted Raceway
4. Telecommunications Outlet Boxes
5. Audio Visual Outlet Boxes
6. Corridor Cable Tray
7. Cable Hangers
8. Related work specified elsewhere:

a. Division 26 – Electrical

C. Related work specified elsewhere:

1. 271423 – Communications Optical Fiber Backbone Cabling
2. 271500.23 – Audio Video Communications Horizontal Cabling
3. 271513 – Communications Copper Horizontal Cabling

1.2 QUALITY ASSURANCE

A. All pathways and associated 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 architect and Owner's Project Manager. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the applicable requirements of the referenced codes and standards:

1. National Electric Code (NFPA 70) including the following Articles:

a. 348 Electrical metallic tubing
b. 349 Flexible metallic tubing
c. 350 Flexible metal conduit
d. 351 Liquid-Tight Flexible metal conduit and Liquid-Tight flexible nonmetallic conduit
e. 352A Surface Metal Raceways
f. 352B Surface Nonmetallic raceways

g. 362 Metal Wireways and nonmetallic Wireways
h. 370 Outlet, Device, Pull and Junction Boxes, Conduit Bodies and Fittings
i. 645 Information Technology Equipment
j. 800 Communications Circuits

2. The following American National Standards Institute (ANSI) standards:

a. ANSI-C80.3 Specification for Electrical Metallic Tubing, Zinc-coated

3. The following Telecommunication Industry Association (TIA) standards:

a. ANSI/TIA 568.1-D Commercial Building Telecommunications Cabling Standard
b. ANSI/TIA 569-E - Commercial Building Standard for Telecommunications Pathways and Spaces.
c. ANSI/TIA 569-E-1 Commercial Building Standard for Telecommunications Pathways and Spaces.
d. ANSI/TIA/EIA 606-C - The Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings. (Including Errata sheet for ANSI/TIA/EIA-606-B).
e. ANSI/TIA-607-C - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

4. The following BICSI guidelines:

a. BICSI Telecommunications Distribution Design Manual (Most Recent Edition)
b. BICSI Telecommunications Cabling Installation Manual (Most Recent Edition)

5. The following UL standards:

a. UL 1, 2000 Flexible Metal Electrical Conduit
b. UL 3, 1999 Flexible Nonmetallic Tubing for Electric Wiring
c. UL 5, 1996 Surface Metal Electrical Raceways and Fittings
d. UL 360, 1996 Liquid-Tight Flexible Steel Conduit, Electrical
e. UL 514B, 1996 Fittings for Conduit and Outlet Boxes
f. UL 797, 1997 Electrical Metallic Tubing
g. UL 870, 1995 Electrical Wireways, Auxiliary Gutters and Associated Fittings

1.3 SUBMITTALS

A. Contractors shall provide product data for all the equipment specified herein.

B. Contractor shall provide all submittals according to Section 27 05 00.

PART 2 - PRODUCTS

2.1 CONDUIT

A. All telecommunications conduits are provided for under Division 26. All conduit and backboxes for telecommunications shall be sized as detailed by the T-series drawings.

B. Conduits and all mounting accessories and supports exposed to public view shall be painted/powder coated a consistent color. Confirm color with architect prior to installation.

2.2 FLOOR BOXES

A. Floor boxes are specified under Div 26 specifications.

2.3 SURFACE MOUNTED RACEWAYS AND TELECOMMUNICATIONS OUTLET BOXES:

A. Surface mounted raceway and outlet boxes shall not be used within the scope of work of this project without prior approval.

2.4 FLUSH MOUNTED TELECOMMUNICATIONS OUTLET BOXES

A. All flush-mounted telecommunications outlet boxes are provided for under Division 26.

B. All connected pathways shall be installed as detailed by the T-series drawings.

C. Boxes shall be a minimum of 4-11/16” W x 4-11/16” L x 2-1/8” D.

D. Mud rings shall be a minimum of 1 gang and the depth required to allow the outlet to be flush with the wall surface.

E. All flush mounted telecommunications outlet boxes shall be properly sized as required by the contract drawings.

F. Acceptable Manufacturers:

1. Appleton
2. Raco
3. Steel City
4. Randl
5. Or Equal

2.5 FLUSH MOUNTED AUDIO VISUAL OUTLET BOXES

A. All flush-mounted audio visual outlet boxes are provided for under Division 26.

B. All connected pathways shall be installed as detailed by the T-series drawings.

C. Boxes shall be a minimum of 4-11/16” W x 4-11/16” L x 3-1/4” D.

D. Mud rings shall be a minimum of 1 gang and the depth required to allow the outlet to be flush with the wall surface.

E. All flush mounted audio visual outlet boxes shall be properly sized as required by the contract drawings.

F. Acceptable Manufacturers:

1. Appleton
2. Raco
3. Steel City
4. Randl
5. Or Equal

2.6 CORRIDOR CABLE TRAY, SUPPORTS, AND ACCESSORIES

A. Wire Mesh Cable Tray

1. Wire mesh cable tray shall be manufactured from round carbon steel wires that are 5 mm and 6 mm in diameter. Wires shall be welded at intersections to form a 2” x 4” (50 mm x 100 mm) grid pattern. The tray shall be U-shaped with equal height sidewalls.
2. Individual tray sections shall be 10’ (3048 mm) long a minimum of 18” (457 mm) wide Sidewalls shall be 4” (100 mm) high.
3. Wire mesh cable tray shall be zinc electroplated after fabrication, galvanized before fabrication (pre-galvanized) or when exposed to public view painted black with powder coat paint, as specified below. Refer to Part 1.6.C of specification 270000 for color selection submittal requirements.
4. Wire mesh cable tray that is 6” (150 mm) wide or wider shall be UL Classified for suitability as an equipment grounding conductor only. Pre-galvanized trays shall be UL Classified in the United States. Painted tray shall be UL Classified in the United States and Canada.
5. Acceptable Manufacturers:

    a. Chatsworth Products (CPI)
    b. Cablofil, CF Series
    c. Cooper B-Line
    d. Hoffman
    e. MonoSystems
    f. MP Husky
    g. Or Approved Equal

B. Wire Mesh Cable Tray Supports

1. Provide a method of attaching cable tray to the ceiling or wall. Ceiling mounted applications shall use trapeze style supports. Wall mounted applications shall use a triangle support bracket.
2. Supports will be sized at minimum to match the width of the wire mesh cable tray that is supported. The support may be wider than wire mesh cable tray.
3. Each support will be punched with a hole-pattern that accepts tray attachment hardware and/or will have tabs that can be bent over the tray wires to secure the tray to the support.
4. Supports will be manufactured from steel.
5. Wire Mesh Cable Tray Supports will be zinc electroplated after fabrication or galvanized before fabrication (pre-galvanized) to match the finish of the cable tray.
6. Cable tray supports shall be as provided from the manufacturer of the cable tray.

C. Wire Mesh Cable Tray Splices and Fasteners:

1. Provide a method of splicing and electrically bonding wire mesh cable tray sections together.
2. Provide a method for securing wire mesh cable tray to the ceiling or wall.
3. Provide a method for attaching wire mesh cable tray directly to the top of racks.
4. Provide a method for attaching an electrical bonding conductor to the wire mesh cable tray.
5. All Splices and fasters shall be from the same manufacturer as the cable tray.

D. Wire Mesh Cable Tray accessories

1. Provide a radius drop to form cable over a smooth curve wherever cable exits or enters the side, bottom or end of wire mesh cable tray.
2. Provide a bracket to fill the gaps between tray sections created when the tray is cut to form a horizontal turn.
3. All cable tray accessories shall be from the same manufacturer as the cable tray.

2.7 CABLE HANGERS

A. Provide prefabricated, zinc coated, carbon steel wide base hangers designed specifically for data communications and audio visual cable installations.

B. Hanger and supports must be NRTL (Nationally Recognized Testing Laboratories) labeled for support of Category 6 and Category 6a cabling.

C. Hangers shall have open top, rolled edges and a 2” to 4” minimum diameter loop as required.

D. Provide beam clamps, rod fasteners, flange clips and brackets as job conditions require.

E. Acceptable Manufacturers:

1. Cooper B-Line
2. Erico
3. Panduit
4. Or Equal

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The intention of the telecommunications conduits is to provide a route between ER and TRs, routes from the TRs throughout building floors to hallways, and routes from hallway distribution systems into rooms to individual drop locations 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.

C. If core drilling for data cabling pathways is planned through a historic building's wall, the existing

wall must be scanned prior to coring to uncover any unforeseen conditions. Verify the conditions of an existing wall with the owner prior to drilling.

D. Support raceways from building construction. Do not support raceways from ductwork piping, or equipment hangers.

E. Support outlet, pull, and junction boxes independently from building construction. Do not support from raceways.

F. Coordinate all raceway runs with other trades.

G. All open raceways shall be installed away from any light fixture or other source of EMI (Electro-magnetic interference).

1. Open cables and cables in nonmetallic raceways and unshielded power:

   a. Electrical less than 2 kVa - 5 inch minimum
   b. Electrical 2 to 5 kVa - 12 inch minimum
   c. Electrical greater than 5 kVa - 24 inch minimum

2. Cables in grounded metallic raceways and unshielded power:

   a. Electrical less than 2 kVa - 2-1/2 inch minimum
   b. Electrical 2 to 5 kVa - 6 inch minimum
   c. Electrical greater than 5 kVa - 12 inch minimum

3. Cables in grounded metallic raceways and shielded power:

   a. Electrical less than 2 kVa - 1 inch minimum
   b. Electrical 2 to 5 kVa - 3 inch minimum
   c. Electrical greater than 5 kVa - 6 inch minimum

4. Cables and electrical motors and transformers 5 kVa or larger - 48 inches
5. Cables and fluorescent fixtures - 5 inches

H. All horizontal pathways shall be bonded and grounded per the NEC Article 250.

I. In all cases, horizontal pathways shall be sized for a minimum of 60% future growth.

J. Horizontal distribution cables shall be bundled in groups of no more than 50 cables. Cable bundle quantities in excess of 50 cables may cause deformation of the bottom cables within the bundle and degrade cable performance.

3.2 RISER CONDUIT

A. A minimum of (2) 4” conduits shall be installed between each TR/IDF room and the ER/MDF location as shown on the Drawings. Additional riser conduits are required for all horizontal data and access control cabling passing between floors. Contractor shall refer to the T-Series floor plans for all minimum required riser conduit locations.

B. Conduits entering TR/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 TR/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 station 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. Junction boxes shall be sized according to reference standards. Conduit fittings in lieu of junction boxes are not acceptable.

E. Conduits shall not be less than 3" trade size and be equipped with a nylon pull cord rated minimum 200 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 Owner. All fire stopping penetrations must be labeled with the UL1479 or ASTM E814 reference number, dated, and signed by the technician who installed the fire stopping material.

G. Bushings and/or connectors on ends of riser conduits are required.

H. Install the 4” conduit waterfall on all 4” conduits containing cables that transition more than 6” vertically.

I. Riser conduits shall not be used for the distribution of horizontal cabling, departmental cabling, or other low voltage systems not related to telecommunications.

3.3 STATION CONDUIT

A. Provide station conduits as required for each data, audio visual, and security location. Contractor shall refer to the T-Series drawings for all conduit requirements for each location.

B. Conduit that is exposed to public view or concealed above inaccessible ceilings shall be continuous to the corridor cable tray distribution system.

C. All conduit shall be 1” EMT minimum or appropriate size as shown on the Drawings or as specified herein for installation of telecommunications cables. No conduit used for telecommunications cabling shall exceed a 40% fill ratio.

D. Provide nylon pull cord in each conduit to hallway skeletal or distribution system.

E. Indelibly mark station conduit at hallway distribution end with Room # that conduit serves.

F. Indelibly mark station conduits that directly enter the telecommunications room.

G. The use of conduit bodies including type LB and LC is prohibited.

H. 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. All junction boxes shall be sized per referenced ANSI/TIA standards. Conduit bodies shall not be used in lieu of junction boxes.

I. Place an appropriate sized junction box in each individual station conduit run that exceeds 100ft in length.

J. The use of a third bend in a conduit is only acceptable if:

1. The total conduit run does not exceed 33ft.
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.

K. Ceiling grid support wires shall not be used to support telecommunications raceways or cables.

L. Station conduits shall not be used for the distribution of departmental cabling or other low voltage systems not related to telecommunications.

M. Conduits shall be anchored so that they are rigid to movement.

3.4 CONDUIT SLEEVES

A. Conduit sleeves shall be EMT.

B. Contractor shall provide the quantity of sleeves as necessary to accommodate the cabling while maintaining 50% spare space capacity in each sleeve for future cables.

C. All sleeves shall have bushings installed and be fire stopped per ANSI/NFPA-70.

D. Primary pathways and ER/TR entrances shall use four-inch sleeves.

E. ER/TR spaces shall be provided with a minimum of four 4-inch sleeved penetrations from the corridor ceiling space for premise cabling.

F. Secondary pathways require a minimum of two-inch sleeves as required.

G. Install a 4” Conduit Waterfall on all 4” conduit sleeves containing cables that transition more than 6” vertically from the sleeve down to another raceway (conduit or cable tray).

H. Install Nylon Cable Protectors in conduits where large amounts of cables enter/exit the conduit system creating pressure on the cables on the leading conduit edge. These protectors would not be used on 4” conduits where the Panduit Waterfall is required (more than 6” of vertical drop).

I. Install EZ Path or similar fire rated sleeves where cables must penetrate fire-rated walls between sections of skeletal conduit or cable tray sections.

3.5 SURFACE MOUNTED RACEWAY

A. Contractor shall not surface any raceways without prior authorization from the Architect.

3.6 CORRIDOR CABLE TRAY SYSTEM

A. Complete wall mounted or suspended cable basket system and necessary accessories shall be provided as shown on plans. Install entire cable basket system in accordance with manufacturer's minimum installation practices and all local governing codes.

B. Coordinate installation of cable tray with other trades to allow a minimum of 12" above, 6" in front, and 3" below of clearance from piping, conduits, ductwork, etc.

C. Submittal drawings, including of 8 ½" x 11" catalog cut sheets, shall be provided for the following items: cable tray, fittings, accessories and load data.

D. Cable tray shall not be loaded beyond 60% of manufacturer's recommended load capacity.

E. Where a new cable basket distribution system encounters a wall, install sufficient 4" EMT sleeves or STI EZ Path fire stopping sleeves through the wall so cabling does not exceed 20% fill.

F. Where cable basket is exposed below ceiling, install the appropriate solid bottom inserts to conceal cables.

G. Install cable basket dropouts where large quantities of cables exit the distribution system.

H. Provide factory manufactured tee fittings and 90 degree fittings to maintain the tray performance characteristics. Utilize factory splice connectors to maintain the tray ground integrity.

3.7 CABLE HANGERS

A. J-hooks shall be installed per ANSI/EIA/TIA 569 Commercial Building Standards for Telecommunications Pathways and Spaces.

B. Provide cable hangers a maximum of 5' on center wherever cable tray or conduit is not present.

C. Load hangers as recommended by the manufacturer. Provide hangers side by side on a common bracket where cable quantities require.

D. Do not install cables loose above lock-in type, drywall or plaster ceilings.

E. Cable hangers shall be installed a minimum of six (6) inches and a maximum of thirty six (36) inches above the ceiling tiles. Cable hangers and cabling shall not touch the ceiling.

F. Do not support cable from ceiling system tie wires or grid in fire rated systems.

3.8 TELECOMMUNCATIONS OUTLET BOXES

A. Contractor shall provide and install all outlet boxes according to all applicable codes and standards.

B. Provide the quantity and size to complete the scope of work as required by the contract documents.

C. Contractor shall install all outlet boxes and device rings according to the manufacturer recommendations and requirements.

D. Boxes shall be installed at the height detailed by the T-series drawings or at the same height as all other electrical outlet locations within each space.

3.9 AUDIO VISUAL OUTLET BOXES

A. Contractor shall provide and install all outlet boxes according to all applicable codes and standards.

B. Provide the quantity and size to complete the scope of work as required by the contract documents.

C. Contractor shall install all outlet boxes and device rings according to the manufacturer recommendations and requirements.

D. Boxes shall be installed at the height detailed by the T-series drawings or at the same height as all other electrical outlet locations within each space.

3.10 SUPPORTING DEVICES

A. Provide steel angles, channels and other materials necessary for the proper support of wall-mounted cabinets, racks, panels, etc.

B. Cabinets, large pull boxes, and cable support boxes shall be secured to ceiling and floor slab and not supported from conduits. Small equipment boxes, etc., as approved by the Architect and Project Manager, may be supported on walls.

C. Racks for support of conduit and heavy equipment shall be secured to building construction by substantial structural supports.

3.11 FIRE STOPS

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 Architect 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 E814 and must be labeled with the UL1479 or ASTM E814 reference number, dated, and signed by the technician who installed the fire stopping material.

END OF SECTION 270528

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PART 1 - GENERAL

1.1 DESCRIPTION

A. The work required under this section consists of providing underground conduits, handholes, raceways, etc., for telecommunications wiring as required for this project.

B. Minimum requirements and installation methods for the following pathways:

1. Handholes
2. Underground Ducts and Raceways

C. Related work specified elsewhere:

1. 271119 – Communications Termination Blocks and Patch Panels
2. 271423 – Communications Optical Fiber Backbone Cabling

1.2 QUALITY ASSURANCE

A. All pathways and associated 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 Architect and Owner's Project Manager. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "Or Approved Equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with requirements of the local Authority Having Jurisdiction. Refer to Section 27 05 00 for all applicable standards and codes.

1.3 SUBMITTALS

A. Contractor shall refer to Section 27 05 00 for all submittal requirements.

PART 2 - PRODUCTS

2.1 UNDERGROUND DUCTS AND RACEWAYS

A. Ducts shall be Schedule 40 PVC or SDR 11 HDPE, sized as shown on the contract drawings. Minimum duct size shall be 2” ID unless noted otherwise.

B. Includes factory installed 1250lb minimum polyester flat woven pull tape in each conduit.

C. Flexible fabric innerduct shall placed within each 2” or larger conduit as required prior to pulling any new cabling within the underground conduit. A minimum of 3 cells shall be installed in each 4” conduit. Each 2” conduit shall have a minimum of 2 innerducts installed.

1. Includes factory installed 1250lb minimum polyester flat woven pull tape in each cell.
2. Smoothwall rigid innerduct shall not be accepted as equal.
3. Acceptable Manufacturers

    a. Maxcell EDGE
    b. Or Approved Equal

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The intention of the telecommunications conduits is to provide a route underground structures and buildings 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.

C. Coordinate all raceway runs with other trades.

3.2 UNDERGROUND DUCTS AND RACEWAYS

A. Ducts shall be trenched or directionally bored as required for installation.

B. Ducts shall be installed with a minimum of 36” of cover.

C. Ducts shall be installed a minimum of 12” from electrical conduits.

D. Ducts shall be separated and held in place with duct spacers at intervals of no more than 8 feet.

E. Corners and bends of duct runs shall be installed with long radius sweeps, encased in concrete.

F. Ducts shall be installed with a minimum of 3” of fall per 100’ toward maintenance holes and away from buildings.

G. Ducts shall be surrounded by a minimum of 3” on all sides with flowable backfill.

H. An orange magnetically detectable warning tape shall be installed above the top of the duct bank, 18” below ground level.

I. Where possible, ducts shall be terminated into precast cutout locations.

J. Ducts penetrating manholes, precast handholes, and building entrance wall penetrations which do not land in a pull box, must be terminated flush to the wall(s) using bell ends.

K. Building entrance ducts which penetrate the floor must extend high enough up for installation of a

bushing to protect the cable sheath from the edges of the conduits, but not much higher to allow for routing of cables leaving the conduits.

L. Duct shall be sealed around their outer edges with hydraulic cement to prevent leakage into manholes and handholes.

M. Unused ducts shall be plugged at both ends using compression type fittings.

N. Seal maintenance hole penetrations using hydraulic cement.

O. Installed Duct Penetration

1. Pull round wood or steel test mandrel of recommended size through each duct from both directions to remove obstructions.
2. Pass a wire brush mandrel and/or a rubber duct swab of appropriate size through each duct until all foreign materials and water are removed.
3. Ducts shall be provided with Greenlee, Muletape, or equal continuous measuring tape in each duct.
4. Unused ducts shall be plugged using compression type fittings.

P. Each conduit shall be supplied with flexible fabric innerduct to assist with future cabling installation.

1. Provide textile innerduct in conduit and wire ways using continuous unspliced lengths of textile innerduct between maintenance holes, pull boxes, and/or termination points as indicated on the drawings.

2. Contractor shall follow all manufacturer recommended installation requirements and documentation.

END OF SECTION 270543

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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes the minimum requirements for the installation, termination, and labeling of all faceplates and connectors as depicted on the Contract Drawings and required by these specifications.

B. Related Sections include the following:

1. 270526 – Grounding and Bonding for Communications Systems
2. 271116 – Communications Cabinets, Racks, Frames and Enclosures
3. 271119 – Communications Termination Blocks and Patch Panels
4. 271500.23 – Audio Video Communications Horizontal Cabling
5. 271513 – Communications Copper Horizontal Cabling
6. 271543 – Communications Faceplates and Connectors

1.2 SUBMITTALS

A. Contractor shall provide all submittals according to Section 270500.

PART 2 - PRODUCTS

2.1 LABELS

A. Products shall provide labeling options that comply with the TIA/EIA-606-B Standard. All products shall be clearly identified. Products shall include faceplates, surface mount boxes, patch panels, marker ties, printers and accessories.

B. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.

C. Shall be preprinted or laser printed type.

D. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable.

E. Where insert type labels are used, provide clear plastic cover over label.

F. A standard style, size 10, bold font type shall be used when making faceplate labels. All label heights shall be the same to allow for consistent labeling. A Cable Management Inventory Record shall be used to record all installation details.

G. Acceptable Manufacturers:

1. Brady
2. Brother
3. Dymo
4. Panduit
5. Or Equal

PART 3 - EXECUTION

3.1 IDENTIFICATION AND LABELING

A. The telecommunications Contractor's onsite representative(s) shall schedule a meeting with the Owner's representative through the appropriate Project Manager prior to the permanent labeling of telecommunications outlets, patch panels, and cabling.

B. Label all horizontal cabling specifically corresponding to where the cable terminates in the ER/TR. Label both ends of each horizontal cable as shown on the drawings or as required by these specifications. Numbers shall be sequential and Contractor shall confirm labeling with Owner prior to installation.

C. Faceplates and Patch Panels:

1. Label faceplates at the Telecommunications Outlets specifically corresponding to the horizontal cable labeling scheme.
2. Labels shall be mounted in a manner which permits easy access and viewing.

D. Telecommunications outlet receptacles, cables, and terminations shall be labeled with a standard identification tag at both the telecommunications outlet and on the patch panels in the ER/TR.

E. Tags shall be preprinted or computer printed with indelible waterproof ink and mechanically secured in a permanent fashion; for example, using an appropriate label maker with 3/8" tape.

F. Handwritten labels are NOT acceptable.

G. Where existing systems are being maintained, utilize the Owner's specific identification scheme.

H. Horizontal Copper Cable Labeling scheme:

1. Horizontal cabling shall be labeled specifically corresponding to where the cable terminates in the ER/TR. Label both ends of each horizontal cabling as follows:
2. Labeling on the cables must be the same on either end of the cable.
3. All labeling will be done in all capital letters.
4. Patch panel labels shall incorporate a room number or identifier for each telecommunications outlet location.
5. Labels shall be sequentially numbered per area or building.
6. Room Numbering

   a. ER/MDF is always: MDF <three-digit building room number>
   b. TRs/IDFs are always: IDF <three-digit building room number>

7. Data and Voice

   a. Telecommunications outlets shall be labeled the following: the ER/TR room number, the rack number as required (R1, R2, etc.) the patch panel letter (A, B, C, D, etc.) and the patch panel port number (01-48). For example, the first port located nearest the hinge side of the door in Room 200 terminated to the first port of the first patch panel in the first rack in MDF 100 would be labeled 100-R1-A-01 at the telecommunications outlet and 200 at port 1 of patch panel A, the second closest port nearest the hinge side of the door working clockwise around the room

would be labeled 100-R1-A-02 at the telecommunications outlet and 200 at port 2 of patch panel A, the third closest port nearest the hinge side of the door working clockwise around the room would be labeled 100-R1-A-03 at the telecommunications outlet and 200 at port 3 of patch panel A, etc.

b. Patch panels shall be labeled with a letter designation on the left side of each patch panel. Patch panels shall be labeled in sequential alphabetical order from top to bottom starting with the letter 'A'. Each patch panel port shall be labeled with the telecommunications outlet room number.

c. Patch cords installed in the ER/TR racks shall be labeled with a number on both ends of the patch cord starting with the number '1' and continuing sequentially from left to right for the total number of terminations installed in the ER/TR.

8. Label faceplates at telecommunications outlet locations specifically corresponding to the horizontal cable labeling scheme.

I. Riser Copper and Fiber Optic Cabling Labeling Scheme:

1. Riser cabling shall be labeled with "MDF <three-digit building room number>" followed by the ER/MDF slot letter designation, followed by "IDF <three-digit building room number>". For example, the fiber optic riser cabling routed from ER/MDF 100 slot G to TR/IDF 105 would be labeled MDF 100-SLOT G-IDF 105. Label both ends of each riser cabling.
2. Label all strands or pairs with a designated number in adherence with the Owner's approved identification scheme.
3. Labeling on the cables must be the same on both ends of the cable.
4. All labeling shall be printed in all capital letters.

J. The identifier shall be inserted into the Outlet ID, between the room number and the Outlet Designator as indicated in the drawings.

K. All labeling shall be coordinated with and approved by an appropriate Owners representative.

1. Schedule a meeting with the Owner's Information Technology representative through the Architect prior to the permanent labeling of Information Outlets and ER/TR patch panels.

L. The contractor is to submit a floor plan to Owner after substantial completion indicating the MAC addresses of the installed wireless access points and their location in the building.

3.2 RECORD COPY AND AS - BUILT DRAWINGS

A. Refer to section 27 05 00 for all record copy and as-built drawing requirements.

END OF SECTION 270553

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PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, and materials unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of all telecommunications infrastructure as described on the Drawings and/or required by these specifications.

1.2 RELATED SECTIONS

A. Related sections include the following:

1. 270526 – Grounding and Bonding for Communications Systems
2. 270553 – Identification for Communication Systems
3. 271116 – Communications Cabinets, Racks, Frames and Enclosures
4. 271119 – Communications Termination Blocks and Patch Panels
5. 271513 – Communications Copper Horizontal Cabling
6. 271543 – Communications Faceplates and Connectors

1.3 INTENT OF DRAWINGS AND SPECIFICATIONS

A. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this Contract whether or not specified or shown on the Drawings.

1.4 SUBMITTALS

A. Contractor shall provide all submittals according to Section 27 05 00.

PART 2 - PRODUCTS

2.1 PRODUCT STANDARDS

A. All materials shall conform with the current applicable industry standards including, but not limited to:

1. NEMA (National Electrical Manufacturers' Association)
2. ANSI (American National Standards Institute)
3. ASTM (American Society for Testing and Materials)
4. ICEA (Insulated Cable Engineers Association)
5. National Electrical Safety Code

B. In addition, all Material shall be Underwriters Laboratories Listed unless otherwise indicated.

C. All products must be new.

2.2 TELECOMMUNICATIONS ROOM PLYWOOD

A. 3/4" (19mm) fire retardant plywood, grade AC or better.

2.3 TELECOMMUNICATIONS ROOM CABLE TRAY

A. Contractor shall provide wall mounted ladder rack cable tray within each telecommunications room as shown on the T-Series drawings. Telecommunications room cable tray shall not be substituted with wire mesh corridor cable tray unless prior authorization has been provided.

B. Tray shall meet the following specifications:

1. Rectangular steel tubular runway with cross members welding at a maximum of 12” (304.8mm) spacing intervals.
2. Metal cable trays with splice connectors, bolts and, nuts for connecting straight lengths and fittings. Cable tray to be constructed with rounded edges free of burrs. Cable tray to be installed and supported according to NEMA standards.
3. Minimum of 12” (304.8mm) wide or as indicated on the contract drawings.
4. UL Listed for suitability as an equipment grounding conductor only.
5. Powder coated black in color.
6. Shall include runway elevation kit as needed.
7. Include all splice kits, ground straps, and support kits as required.
8. Provide all other associated parts as needed.

C. Acceptable Manufactures

1. Chatsworth Products (CPI)
2. Cooper B-Line
3. Middle Atlantic
4. Panduit
5. Ortronics
6. MonoSystems
7. Or Equal

2.4 WALL MOUNTED WIRE MANAGEMENT

A. Contractor shall provide all wall mounted wire management to support horizontal and riser cabling as required within the telecommunications spaces.

B. Wall mounted wire management (d-rings) shall be non-conductive smooth surface with an overall black or white color. Minimum interior dimensions of 3” x 5”.

C. Acceptable manufacturers:

1. Arlington Industries
2. Hoffman
3. Middle Atlantic
4. Panduit
5. Or Equal

PART 3 - EXECUTION

3.1 GENERAL

A. All racks, patch panels, cables, jacks, system components, etc. shall be labeled according to ANSI/EIA/TIA-606 specifications and in coordination with the Owner and Architect.

3.2 EQUIPMENT ROOM FITTINGS

A. New ER/TRs must be free from dust, dirt, and other foreign materials before the installation of any termination hardware or the termination of copper or fiber optic cables. The door to the telecommunication rooms must be permanently installed and closed during termination.

B. Each Contractor shall be knowledgeable of the work to be performed by other trades and take necessary steps to integrate and coordinate their work with other trades.

C. The Contractor shall be responsible for furnishing all materials on the drawings or as specified herein for a complete telecommunications system.

D. All telecommunications infrastructure shall be installed utilizing BICSI installation practices in an aesthetically pleasing and organized fashion. All surface raceway in new buildings must be approved by the Owners Representative and the Architect.

E. All telecommunications infrastructure shall be installed for optimal performance.

F. All telecommunications infrastructure shall be installed to accommodate future moves, adds, and changes.

G. All work performed in occupied spaces shall be in a manner that allows the Owner to operate the existing facilities on a continuous basis.

3.3 BACKBOARDS

A. Install 3/4" fire-retardant plywood vertically on one wall from 0' 6" to 8' 6" AFF.

1. Place C grade surface towards the wall.
2. Backboards shall be painted with two (2) coats of fire retardant paint on all sides, or fire-retardant treated and painted.
3. Backboard paint color shall be white.

B. No mechanical/electrical equipment or conduits shall be installed on or across the plywood or impair the routing of telecommunication cables.

C. Fire-retardant stamp must be visible.

3.4 TELECOM ROOM CABLE TRAY

A. Install cable tray in telecommunications room as shown on drawings. Shall be supported at a minimum of every 5’.

B. Install cable tray above all equipment frames and securely attach both ends of cable tray. Cable tray and equipment frame shall be secured so that the top of the equipment frame cannot move. Ladder rack also shall be installed perpendicular to and secured to the outward end of the equipment rack(s).

C. Install horizontal cable tray at a minimum of 7' 2" AFF to the bottom of the tray.

D. Install additional horizontal and vertical sections of cable tray on walls where riser cables, and large bundles of horizontal cables route from conduits entering/exiting the room.

E. Horizontal cable tray routed within the ER/MDF shall be installed in such a way that the route for future “unprotected” OSP cabling does not pass through, on, or in front of the cable tray containing "unprotected" UTP cabling.

3.5 WALL MOUNTED WIRE MANAGEMENT

A. Install wall mounted wire management (d-rings) on plywood as specified herein or shown on drawings.

B. Install wall mounted wire management (d-rings) horizontally and vertically on plywood backboard to manage horizontal cables that enter the telecommunications room from below up to the cable tray. Route these horizontal cables to the nearest corner of the room to maximize wall space.

END OF SECTION 271100

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, and materials unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of all communications cabinets, racks, and enclosures as described on the T-series Drawings and/or required by these specifications.

B. This section includes the minimum installation requirements for equipment and cabling infrastructure in Equipment Rooms and Telecommunication Rooms, and includes the following:

1. Floor Mounted Equipment Cabinet
2. Rack Mounted Vertical Wire Management
3. Rack Mounted Horizontal Wire Management

C. Related Sections include the following:

1. 270526 – Grounding and Bonding for Communications Systems
2. 270553 – Identification for Communication Systems
3. 271100 – Communications Equipment Room Fittings
4. 271119 – Communications Termination Blocks and Patch Panels
5. 271513 – Communications Copper Horizontal Cabling

1.2 QUALITY ASSURANCE

A. All telecommunications 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 approval of the Architect and Owner's Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270500 for all applicable standards and codes.

1.3 SUBMITTALS

A. Contractor shall provide all submittals per Section 270500.

PART 2 - PRODUCTS

2.1 FLOOR MOUNTED EQUIPMENT CABINETS

A. Contractor shall provide data equipment frames as shown on the drawings or as specified herein.

B. Racks shall meet the following minimum specifications:

1. Black powder coated aluminum or minimum 14 gauge steel construction.
2. Universal 19” mounting rails with 10/32 and 12/24 tapped holes in EIA universal 5/8”, 5/8”, ½” mounting hole pattern.
3. Minimum overall dimensions of 84”H (45 RU) x 32-36” D x 30” W.
4. All Cabinets within a building are to have identical keys for the MDF and IDF cabinets
5. Shall have both front and rear perforated doors. Rear doors may be split. All doors shall be removable.
6. Side panels shall be solid, removable, and with the ability to be locked.
7. Each cabinet shall be provided with adjustable feet to allow each unit to be leveled.

C. Acceptable Manufacturers:

1. CPI
2. Cooper B-Line
3. Hubbell
4. Middle Atlantic
5. Panduit
6. Or Approved Equal

2.2 RACK MOUNTED VERTICAL WIRE MANAGEMENT

A. Provide vertical wire management as required for each equipment rack as shown on the contract drawings. Unit shall be mounted to the front and rear of each rack.

B. Each unit shall be minimum 6” wide or owner approved width, 45 RU high, and provide both a front a rear wire management channel.

C. Contractor shall match manufacturer to that of the specified floor mounted equipment rack.

D. Acceptable Manufacturers:

1. CPI
2. Hoffman
3. Hubbell
4. Middle Atlantic
5. Panduit
6. Or Approved Equal

2.3 HORIZONTAL WIRE MANAGEMENT

A. Provide horizontal wire management as required for each equipment rack as shown on the contract drawings.

B. Contractor shall match manufacturer to that of the specified floor mounted equipment rack.

C. Contractor shall provide and install horizontal wire management above and below each patch panel

D. Horizontal wire management shall meet or exceed the following specifications:

1. Shall be plastic with integral wire retaining fingers.
2. Shall have front and back channels.
3. Shall be a minimum 3” x 3” deep on front channel and 3” x 3” on rear channel.
4. Shall be rated at minimum to hold 48 cables in the front and rear compartments.

E. Acceptable Manufacturers:

1. Commscope
2. Hubbell
3. Middle Atlantic
4. Ortronics
5. Panduit
6. Or Approved Equal

PART 3 - EXECUTION

3.1 FLOOR MOUNTED EQUIPMENT FRAMES, RACKS, CABINETS AND WIRE MANAGMENT

A. The equipment racks, frames, and cabinets shall be installed in the ER/TRs according to layout and communication media requirements. Placement of racks, frames, and cabinets shall be done in accordance with the T-Series drawings and/or the approved shop drawing of the room layout. All questions regarding rack placement or room layout shall be directed in writing to the Owner.

B. The rack shall be anchored to the floor and braced overhead with ladder racking, and grounded to the ground bus bar location in the ER/TR with a #6 solid or stranded ground wire.

C. Provide vertical and horizontal cable management as required by the contract drawings, this specification, or requested by the Owner.

END OF SECTION 271116

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PART 1 - GENERAL

1.1 DESCRIPTION

A. All horizontal and riser cabling shall be terminated in the designated ER/MDF or TRs/IDFs as detailed within the T-series drawings.

B. This section includes the minimum installation requirements for termination blocks and patch panels in Equipment/Telecommunication Rooms and includes the following:

1. Category 6a Patch Panels
2. Category 6a Patch Cables
3. Optical Fiber Patch Panel Systems
4. Optical Fiber Patch Cables
5. Optical Fiber Connectors

C. Related Sections include the following:

1. 270526 – Grounding and Bonding for Communications Systems
2. 270553 – Identification for Communications System
3. 271100 – Communications Equipment Room Fittings
4. 271116 – Communications Cabinets, Racks, Frames and Enclosures
5. 271513 – Communications Copper Horizontal Cabling
6. 271543 – Communications Faceplate a Connectors

1.2 QUALITY ASSURANCE

A. All telecommunications 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 approval of the Architect and Owners Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where “or equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270500 for all applicable standards and codes.

1.3 SUBMITTALS

A. Refer to section 270500 for submittal requirements.

PART 2 - PRODUCTS

2.1 CATEGORY 6A PATCH PANELS

A. All patch panels shall be in accordance with ANSI/TIA 568C-2 (or latest).

B. Each panel shall be equipped with empty openings for eight position, modular jacks with insulation displacement connectors, rear cable-management bars/standoffs and front label designation strips.

C. Shall be flat patch panels.

D. Provide 24 or 48 port patch panels for termination of horizontal cabling as required. When the ER or TR serves more than one floor, sequentially group the cables by floor on separate patch panels.

E. Acceptable Manufacturers:

1. Belden
2. CommScope
3. Hubbell
4. Leviton
5. Ortronics
6. Panduit
7. Or Approved Equal

2.2 CATEGORY 6A PATCH CABLES

A. Owner shall provide and install color-coded Category 6 rated patch cables for each terminated data port within scope of the project.

2.3 OPTICAL FIBER PATCH PANEL SYSTEMS

A. FIBER OPTIC PATCH PANELS

1. Fiber-Optic patch panels shall be mounted in equipment racks.
2. Fiber-Optic patch panels shall be rack-mounted and shall be 24/48/72/144 port, or as required by the T-series drawings. Size shall not exceed 4 RU of mounting space.
3. Slide-out drawer to provide front access to fibers.
4. Provide duplex LC type UPC couplers for all fiber optic cables.
5. Owner shall provide and install all fiber optic patch cables as required.
6. Acceptable Manufacturers:

a. Belden
b. Corning
c. Commscope
d. Hubbell
e. Leviton
f. Ortonics
g. Panduit
h. Or Approved Equal

B. FIBER OPTIC CONNECTORS

1. Terminate optical fibers with factory-terminated LC connectors. Match fiber cable type provided. If the contractor field terminates individual connectors, methodology shall meet all minimum specifications of equivalent factory terminated solution.
2. Provide Fiber-Optic Fusion Splice Trays for connecting the factory terminated LC pigtails to the associated single-mode fibers.

3. Slide-out drawer to provide front access to fibers.
4. Acceptable Manufacturers

    a. Belden
    b. Corning
    c. Commscope
    d. Hubbell
    e. Leviton
    f. Ortonics
    g. Panduit
    h. Or Approved Equal

PART 3 - EXECUTION

3.1 GENERAL

A. All cables shall be neatly “dressed out” in equipment/telecommunication rooms and throughout project.

B. Fire-stop all sleeves and conduit openings after the cable installation is complete.

3.2 CATEGORY 6A PATCH PANELS

A. Install according to manufacturer instructions and recommendations.

B. Locations and quantity shall be as shown on the T-Series drawings and as required for all Category 6a cable terminations.

C. Provide appropriate blank keystone inserts as needed to fill unused ports.

3.3 OPTICAL FIBER PATCH PANEL SYSTEM

A. Install all patch panels and according to manufacturer instructions and recommendations.

B. Locations and quantity shall be as shown on the T-Series drawings and as required for all backbone fiber optic cabling cable terminations.

END OF SECTION 271119

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of optical fiber backbone infrastructure as described on the Contract Drawings and/or required by these specifications.

1.2 RELATED SECTIONS

A. Related Sections include the following:

1. 270528 - Pathways for Communications Systems
2. 271119 - Communications Termination Blocks and Patch Panels
3. 271513 - Communications Copper Horizontal Cabling
4. 271543 - Communications Faceplates and Connectors

1.3 QUALITY ASSURANCE

A. All 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 approval of the Owner. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where “or equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

1.4 SUBMITTALS

A. Refer to Section 270500 for submittal requirements.

PART 2 - PRODUCTS

2.1 INTRA-BUILDING FIBER OPTIC BACKBONE CABLING

A. Main Equipment Room (ER/MDF) to each Telecommunications Room (TR/IDF) fiber optic backbone cable system.

1. General

a. Provide a new OS2 single mode optical fiber backbone system, as required by the contract drawings, for connecting each IDF/TR to the MDF/ER.
b. Provide all required hardware and enclosures for OS2 optical fiber.

2. Single Mode Fiber Optic Cable

a. Provide a single mode, fiber-optic cable between the Equipment Room (MDF/ER) and each associated Telecommunications Room (TR/IDF).

b. Single mode, fiber-optic cable shall be 9/250µm, OS1/OS2 type.
c. Single mode, fiber-optic cable shall be tight buffer indoor rated.
d. Single mode, fiber-optic cable shall be installed shall have an overall aluminum interlocking armor with a yellow plenum rated jacket (OFCP)
e. Single-mode, fiber-optic cable should be a minimum of 12 Strands. Refer to T-series drawing for required fiber optic strand cabling counts.
f. The single mode fibers shall be terminated with fusion-spliced, factory-polished OS2 pigtails with LC connectors or pre-terminated backbone fiber with associated fiber cassettes.
g. Owner shall furnish and install all fiber optic patch cords.
h. The OS2 fiber backbone system should include all manufacturer recommended enclosures, adaptors, coupler plates, wire management, and accessories for a complete and functional system.
i. The contractor shall be responsible for fully testing and certifying all fiber optic cable runs to ensure fiber shall support connectivity to ethernet switches. If any fiber is deemed to be damaged or unusable; the contractor shall notify the Construction Manager and Owner in writing. Owner will, at their discretion, repair or seek additional services from Contractor to repair defective fiber.

B. Acceptable Manufacturers:

1. Belden
2. Corning
3. Commscope
4. Prysmian/General Cable
5. Hubbell
6. Superior Essex
7. Or Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fiber optic cables and devices in accordance with industry standards and manufacturer's written instructions.

B. Install fiber optic cable without damage to fibers, cladding, or jacket.

1. Ensure that media manufacturer's recommended pulling tensions are not exceeded.

C. Do not bend cables to smaller radii than the minimums recommended by the manufacturer.

D. Use a pulling means, including fish tape, rope, and basket-weave grips, that will not damage media or raceway. Install fiber-optic cable simultaneously where more than one cable is being installed in the same raceway.

E. Use pulling lubricant where necessary; compound used must not deteriorate cable materials. Do not use soap.

F. NO cable splices are allowed. Cable runs to be continuous between all MDF/ER/IDFs/TRs.

G. Provide grounding connections for fiber-optic cable and other system components as required by specifications and applicable codes and regulations, according to manufacturer's written instructions.

H. Provide termination of all fiber-optic cables according to applicable standards and codes.

I. Fiber-optic cable will have cable ID and strand count clearly marked on the fiber cabinet in the ER/TR.

3.2 LABELING

A. All racks, patch panels, cables, jacks, system components, etc. shall be labeled according to ANSI/EIA/TIA-606-B standard and in coordination with the owner and design team.

B. All Fiber-Optic cables shall be equipped with a self-laminating, wrap-around, machine printed label at both ends of the cable.

C. All Fiber-Optic Patch Panels shall be equipped with pre-printed, cable identification designation strips installed behind clear plastic label holders on the front of the patch panel.

D. Contractor shall complete labeling according to section 27 05 53.

3.3 TESTING OF FIBER CABLES

A. GENERAL

1. It will be the Contractor's responsibility to provide the test equipment necessary and document the campus telecommunication coordinator the test equipment available for testing and the last date of certification.
2. Cables will have SC connectors installed on single mode cables prior to testing.
3. The tests shall be performed on inter-building fiber cables.
4. Testing Equipment

    a. Continuity tester
    b. Visible fault detector
    c. Power meter and light source
    d. OTDR (Optical Time Domain Reflectometer)
    e. Appropriate types of fiber-optic jumpers
    f. Equipment for two testers to communicate
    g. Other equipment as approved by designated Owners personnel and as required to complete the testing to the satisfaction of the Owner and design team.

5. Prior to usage, test equipment and components in accordance with manufacturer's published test procedures.
6. All fibers will be tested bi-directionally per TIA-526-7 and TIA-526-14 method A-2.
7. Bi-directional attenuation figures in decibel (dB) will be documented.

a. Before testing, verify with the Owner's Information Technology Services representative if raw or referenced readings are preferred.

8. All strands shall test good and meet current ANSI/TIA/EIA-568 specifications. Dark fibers and excessive attenuation due to breaks, bends, bad splices, defective connectors and bad installation practices will not be accepted and must be corrected.
9. Replacement fiber cables shall be subject to tests and criteria as described in this document.
10. All new fiber cables shall have NO bad fibers. New fiber cables tested to have bad fibers and determined to be non-repairable by practices acceptable to the Owner, shall be replaced at no additional cost to the Owner.
11. Any and all measures taken to correct unacceptable test results shall be recorded, along with loss measurements taken before and after corrective measures.
12. Documentation will include cable ID, origin and destination points, strand ID, and bi-directional attenuation figures in dB, per TIA Method A-2.
13. Use of an OTDR may require that a "launch reel" be used to overcome the OTDR's dead zone, if needed for fault location if the bi-directional tests fail.
14. Fiber jumpers used with the OTDR, light source and power meter must be of the same size and type of the fiber being tested.
15. Fiber jumpers used with the light source and power meters shall be zeroed out by attaching the jumper from the light source via a coupler to the jumper from the power meter.

    a. This reading noted, it will become the reference level to obtain a true attenuation reading (some power meters can be zeroed to allow reading the attenuation level direct).
    b. TIA-526-7 and TIA-526-14 Method A-2 should be used to zero OLTS.

3.4 LOSS BUDGETS

A. Average splice loss shall not exceed 0.35 dB attenuation for multimode, or 0.25 dB attenuation for single mode, measured from both directions.

B. No individual splice, multimode or single mode, shall exceed 0.50 dB attenuation, measured from both directions.

C. No termination shall exceed 0.40 dB attenuation for multimode, or 0.30 dB attenuation for single mode. No single mode OSP fiber shall exceed 0.000091436 dB attenuation per foot (0.25 dB attenuation per kilometer) at 1550 nm.

D. Acceptable maximum allowable attenuation per spliced and terminated fiber will be determined by the following formula:

$$MAX = (S * MS) + (E * ME) + (F * MF)$$

Where:
S = Number of splices in fiber between end termination points.
MS = dB maximum average allowable attenuation per splice.
E = Number of endpoint terminations (namely, 2).
ME = dB maximum allowable attenuation per endpoint termination.

F = Number of feet of fiber from endpoint termination to endpoint termination.
MF = Manufacturer's specification for maximum allowable fiber attenuation per foot of fiber. (Converted from dB per km by formula - dB per km / 3280.8)

3.5 BACKBONE AND RISER FIBER CABLE TESTING

A. Contractor shall test multimode riser fiber at 850 nm and 1300 nm in both directions.

B. No multimode riser fiber shall exceed 0.00021336 dB attenuation per foot at 1300 nm, 400 Mhz bandwidth. (0.70 dB attenuation per kilometer at 1300 nm, 400 Mhz bandwidth).

3.6 WARRANTY AND CERTIFICATION

A. System shall carry an industry standard, application and performance based warranty, by the manufacturer and contractor, for a period of at least 15 years on the new fiber optic cabling; including cabling, patch panels, patch cables, terminations and labor. The remaining portions of the system shall be warranted for a period of one (1) years from date of substantial completion.

END OF SECTION 271423

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PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section includes the minimum requirements for the installation, configuration, and training of the audio-visual components as depicted on the Drawings and required by these specifications.

B. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether specified or shown on the drawings or not.

C. This section includes minimum requirements for the following:

1. Balanced Microphone / Line Level Cabling
2. Loudspeaker Cabling
3. UTP Cabling
4. STP Cabling
5. HDMI Cabling
6. USB Cabling
7. RF Cabling
8. Custom Faceplates and Panels
9. Grommeted Faceplates
10. HDMI Panel Mount Connectors
11. RJ-45 Panel Mount Connectors

D. Related Sections include the following:

1. Division 26 – Electrical
2. 27 05 00 – Common Work Results for Communications
3. 27 05 28 – Pathways for Communications Systems
4. 27 15 13 – Communications Copper Horizontal Cabling
5. 27 51 23 – Central Sound and Paging System
6. 27 41 16 – Integrated Audio Video Systems and Equipment

1.2 QUALITY ASSURANCE

A. The following industry Standards are the basis for the audio-visual systems described herein. The list is incorporated by this reference to them.

1. ANSI - American National Safety Institute.
2. ASTM - American Society of Testing and Materials.
3. EIA - Electronics Industries Association.
4. FCC - Federal Communications Commission.
5. NEMA - National Electrical Manufacturer’s Association.
6. OSHA - Occupational Safety and Health Administration.
7. NEC - National Electric Code.
8. NFPA - National Fire Protection Association, NFPA-70.
9. IEEE - Institute of Electrical and Electronics Engineers.

10. ISO - International Standards Organization.
11. UL - Underwriters Laboratories.
12. BICSI Telecommunications Distribution Methods Manual (TDMM).
13. Davis and Davis, Sound System Engineering (2nd Edition), Howard W. Sams, 1987.
14. Giddings, Audio System Design and Installation (ASDI), Howard W. Sams, 1990.

B. All cable 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 Technology Consultant and Owners Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "Or Approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270500 for all applicable standards and codes.

D. Contractor should have the following qualifications:

1. Experienced in the installation of systems similar in complexity and scale to those included within the scope of work. If requested, the Contractor shall provide the names, locations, and points of contact for at least three installations of the type and complexity specified herein.
2. Within the last two (2) years, installed an audio-visual system with similar equipment and functionality.
3. Have at least one (1) person on staff with CTS-I certification.

1.3 SUBMITTALS

A. Contractor shall provide all submittals according to Section 27 05 00.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Equipment and components shall arrive onsite properly protected and undamaged with containers, packaging and labels intact.

B. Store, handle and protect materials and equipment in accordance with Manufacturer's recommendations.

C. Store materials and equipment in dry, environmentally controlled space. Do not install equipment and materials until spaces are enclosed, watertight, and dry. Protect equipment from dust and other airborne materials.

D. Provide additional protection during handling as necessary to prevent breaking, scraping, marring, or otherwise damaging products or surrounding areas.

E. Protect all equipment and components that are to be installed within this project from theft, vandalism, and exposure to rain, freezing temperatures and direct sunlight.

F. Protect installed equipment and components from damage and prevent use by unauthorized persons.

1.5 WARRANTY

A. The Contractor shall warranty the completed work for a period of one (1) years, from the date of acceptance of the work, to be free of defect in design, workmanship, or material.

B. Contractor shall repair, adjust, and/or replace, whichever the Owner determines to be in its best interests, any defective equipment, materials, or workmanship, as well as such parts of the work damaged or destroyed by such defect, during the warranty period, at the Contractor's sole cost and expense. If parts or components need to be repaired, then a loaner will be supplied and installed until the part or component can be repaired and reinstalled.

C. All service work shall be performed by manufacturer-certified technicians.

D. Contractor to provide the Owner with a phone number for technical support. All support calls shall be answered within twenty-four (24) hours. All repairs shall be underway within forty-eight (48) hours and completed (or loaner supplied) within seven (7) days.

E. If the Contractor does not affect repair within forty-eight (48) hours from the date of notification of such defect, the Owner may secure repair services from other sources and charge the Contractor for such costs without voiding the warranty.

F. At the end of the warranty period, the Contractor shall complete one (1) site visit to evaluate the status of the audio-visual systems. All equipment within this scope of work found to be defective shall be replaced at no cost to the Owner.

G. Guarantees of material, equipment, and workmanship running in favor of the Contractor shall be transferred and assigned to the Owner on completion of the work and acceptance of said work by the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. All electrical conductors installed under this contract, unless otherwise specified, shall be soft drawn annealed stranded copper having a conductivity of not less than 98% of pure copper and meet appropriate ratings.

C. Cable shall carry appropriate fire rating on jacket of cable.

D. Provide plenum rated cable where required.

E. If cabling type is not listed, provide cabling according to manufacturer's recommendations.

2.2 BALANCED MICROPHONE / LINE LEVEL CABLING

A. Contractor shall provide and install microphone/line level cabling as required.

1. Provide cabling that meets or exceeds the following specifications:

a. Minimum shielded 22 AWG, 7x30 stranded cabling.

b. Nominal conductor to conductor capacitance: 114 pF/m.
c. Tinned copper drain wire.
d. Provide pre-molded cables in lengths as required. Refer to the T-series drawings for connector requirements.
e. Cable to be PVC jacketed.

2. Acceptable Manufacturers

a. Belden
b. Liberty
c. West Penn Wire
d. Windy City Wire
e. Or Approved Equal

2.3 LOUDSPEAKER CABLING

A. Contractor shall provide and install loudspeaker cabling as required.

1. Provide speaker cabling that meets or exceeds the following specifications:

a. Cable shall be minimum unshielded 16 AWG. Diameter smaller than 16 AWG is not acceptable.
b. Reference tables in part 3.3 for loudspeaker cabling type(s) required based on system and length.

2. Acceptable Manufacturers

a. Belden
b. Windy City Wire
c. Or Approved Equal

2.4 UTP CABLING

A. Contractor shall provide and install UTP cabling as required per manufacturer's recommendations.

1. Provide UTP cabling meeting the following specifications.

a. Minimum 24 AWG, eight (8) conductor cable
b. Minimum category 6
c. Nominal conductor to conductor capacitance: 15 pF/ft

2. Acceptable Manufacturers

a. Belden
b. Commscope
c. General Cable
d. Superior Essex
e. Or Approved Equal

2.5 STP CABLING

A. Contractor shall provide and install STP cabling as required per manufacturer's recommendations.

1. Provide STP cabling that meets or exceeds the following specifications:

a. Minimum 24 AWG, eight (8) conductor cable
b. Minimum category 6
c. Nominal conductor to conductor capacitance: 15 pF/ft
d. Cable shall be shielded.

2. Acceptable Manufacturers

a. Belden
b. Crestron
c. Extron
d. Or Approved Equal

2.6 HDMI CABLING

1. Contractor shall provide and install HDMI cabling as required. HDMI cabling shall meet or exceed the following specifications.

a. Provide pre-molded cables in lengths as required.
b. Any lengths greater than 25ft shall utilize optical fiber active HDMI cabling. Copper is not acceptable for lengths over 25 feet.
c. Shall support HDMI signal transmission up to 328 ft. via optical cabling.
d. Shall support up to 4K 60Hz 4:4:4 HDR video.
e. Shall meet HDMI 2.0/HDCP 2.2 testing standards.
f. Shall be plenum rated where required.
g. Shall not require external power.

2. Acceptable Manufacturers

a. FSR HDMI 2.0 Digital Ribbon Cables
b. Extron HD Pro Plenum
c. Kramer AV CP-AOCH/60
d. Crestron
e. Or Approved Equal

2.7 USB CABLING

A. Contractor shall provide and install USB cabling as required. USB cabling shall meet or exceed the following specifications:

1. Provide pre-molded cables in lengths as required.
2. Shall support USB 2.0
3. Cable shall be plenum rated if routed through plenum spaces.
4. Acceptable Manufacturers:

a. C2G

b. Extron
c. Crestron
d. Or Approved Equal

2.8 RF CABLING

A. Contractor shall provide and install RF cabling as required meeting the following specifications:

1. Provide RG-8X type cable for runs over 50'.
2. Provide RG-58 type cable for runs up to 50'
3. Center conductor 16 AWG solid (RG-8)
4. Gas-injected FPE insulation
5. Cable to be PVC jacketed.
6. Pre-terminated, manufactured cabling is acceptable provided it meets or exceeds these requirements.
7. Cable shall be plenum rated if routed through plenum air spaces.
8. Acceptable Product:

a. Belden
b. Liberty
c. West Penn Wire
d. Windy City Wire
e. Times Microwave Systems
f. Shure
g. Or Approved Equal

2.9 CUSTOM FACEPLATES AND PANELS

A. Contractor shall provide plates and panels as required by the T-series drawings. Engrave as shown on the drawings.

B. Contractor shall coordinate plate and panel finish and color with the Owner. Plastic plates are not acceptable.

C. Plate and panel label engraving shall be 1/8 in. block sans serif characters unless noted otherwise. On dark plates, letters shall be white; on stainless steel or brushed natural aluminum plates, letters shall be black.

D. Custom and/or engraved plates/panels:

1. Custom panels constructed of 1/8 inch brushed aluminum.
2. Acceptable Manufacturer:

a. ProCo
b. RCI Custom
c. Entertainment Mfg. Group
d. Or Approved Equal

2.10 GROMMETTED FACEPLATES

A. Contractor shall provide grommeted faceplates as needed by audio and video locations as shown on the T-series drawings.

B. Grommet faceplates shall provide a minimum of 1.5” Diameter opening for cable pass-through unless otherwise noted.

C. Contractor shall coordinate plate finish and color with the architect.

D. Grommeted plates/panels:

1. Custom panels constructed of 1/8 inch brushed aluminum
2. Acceptable Manufacturer:

    a. ProCo
    b. RCI Custom
    c. Entertainment Mfg. Group
    d. Or Approved Equal

2.11 HDMI PANEL MOUNT CONNECTORS

A. Contractor shall provide the quantity of HDMI couplers as shown on the T-series drawings.

B. Provide HDMI coupler meeting the following specifications:

1. HDMI coupler shall be panel mounted with metal shell.
2. HDMI coupler shall be female.
3. HDMI coupler shall utilize bronze contact solder terminations.
4. HDMI coupler shall be a minimum HDMI 2.0 compliant.
5. Acceptable Manufacturers:

    a. Neutrik
    b. Switchcraft
    c. Or Approved Equal

2.12 RJ-45 PANEL MOUNT CONNECTORS

A. Contractor shall provide the quantity of Ethernet jacks as shown on the T-series drawings.

B. Provide Ethernet jack meeting the following specifications:

1. Ethernet jack shall be panel mounted with metal shell
2. Ethernet jack shall utilize bronze contact solder terminations.
3. Shell color shall match plate finish.
4. Acceptable Manufacturers:

    a. Neutrik
    b. Switchcraft
    c. Or Approved Equal

PART 3 - EXECUTION

3.1 GENERAL

A. Run wire with conduit, exposed above accessible ceilings, below accessible floors, cable trays and in riser rooms.

B. Provide plenum cabling where required.

C. Utilize cable trays wherever possible. If J-hooks are used, cables shall be supported at a maximum of 5 feet intervals. Cables shall not rest on light fixtures, ceiling tiles, conduits, sprinkler pipes, HVAC ducting, or any other building structure. Provide appropriate support for all horizontal to vertical transitions to keep weight of cable from damaging the point of transition.

D. Horizontal cabling shall be in groups of no more than 60 cables when supported by J-hooks.

E. Cable runs shall be continuous from device location to the final point of termination. Properly installed transition points are acceptable.

F. Provide plastic cable ties or Velcro straps to bundle cabling. Electrical tape or adhesive backed cable ties are not acceptable.

G. Isolate cabling of different signals to minimize crosstalk. Separate wiring between microphone/line level circuits, loudspeaker circuits, and power circuits.

H. Dress, lace, and/or harness all wiring and cabling to prevent mechanical stress on electrical connections. Neatly tie cabling in bundles with cable lengths cut to minimize excess slack.

I. Provide adequate service loops to allow equipment racks to be pulled out for servicing.

J. To prevent against electrostatic hum, on unused shields, fold back shield over cable jacket and cover with heat-shrink tubing. Do not cut off unused shield.

K. Provide code compliant fire proofing techniques for all penetrations of fire rated partitions and slabs.

L. Provide grommets and strain relief material where necessary to avoid abrasion of wire and excess tension on wire and cable.

3.2 COMPONENT CONNECTIONS

A. Prepare wire ends for attachment to components in accordance with manufacturer recommendations.

B. Wire nuts shall not be an acceptable means of connecting wire or cable.

3.3 LOUDSPEAKER CABLING GAUGE REFERENCE

A.

4 OHM & 8 OHM LOUDSPEAKER SYSTEMS		
MAX 2-WIRE COPPER LOUDSPEAKER CABLE LENGTHS (IN FEET) FOR MAX 0.5 Db LOSS IN SPL (11% LOSS IN WATTS)		
WIRE GAUGE	4 OHM SPEAKER LOAD	8 OHM SPEAKER LOAD
10	120	240
12	75	150
14	50	100

16	30	60

B.

70 VOLT LOUDSPEAKER SYSTEMS			
MAX 2-WIRE COPPER LOUDSPEAKER CABLE LENGTHS (IN FEET) FOR MAX 0.5 Db LOSS IN SPL (11% LOSS IN WATTS)			
WIRE GAUGE	7.5W SPEAKER LOAD	15W SPEAKER LOAD	30W SPEAKER LOAD
10	20,000	10,000	5,000
12	12,400	6,200	3,100
14	7,600	3,800	1,900
16	4,800	2,400	1,200

3.4 LABELING

A. Cables, jacks, system components, etc. shall be labeled according to ANSI/EIA/TIA-606-B specifications and in coordination with the Owner/Technology Consultant.

B. All Audio-Video cables shall be equipped with a self-laminating, wrap-around machine printed label at both ends of the cable.

C. Provide legible cable and wiring label permanently affixed for easy identification.

D. Cover labels with clear heat-shrink tubing.

E. Hand-written labels are not acceptable.

F. Locate the cable designator at the origination and destination of each circuit within 3 inches of the termination.

3.5 AUDIO VIDEO PLATE INSTALATION

A. Install plate mounted connectors rigidly attached to plates, plumb and level.

B. Install XLR type connectors in accordance with IED-268 standard, with the following wiring scheme:

1. Pin 1 - Screen (shield)
2. Pin 2 - Hot (high)
3. Pin 3 - ground (low)

3.6 TESTING

A. The audio-video wiring system and associated systems shall be tested end-to-end complete.

3.7 SYSTEM ACCEPTANCE

A. Contractor shall demonstrate to the Owner that all systems have been installed per the plans and specifications and that all programming functions, display functions, control functions and all interfaced equipment operate as expected.

B. Contractor shall demonstrate to the Owner that all the end user staff has a working knowledge of how to operate the installed equipment and that the facilities staff also has a working knowledge of the troubleshooting methods for non-critical service problems.

C. Contractor shall have a Delivery and Acceptance form signed by the Owner representative, agreeing that the installation is complete and its operation is acceptable except as noted on the Delivery and Acceptance form. This will also serve as the start of the warranty period.

D. Contractor shall work with the General Contractor to complete all punch lists and work required to allow the General Contractor to close out his project in a timely manner. This will include but not limited to any work that would impact any final inspection for turnover of the building

END OF SECTION 27 15 00.23

PART 1 - GENERAL

1.1 DESCRIPTION

A. Horizontal cabling is the portion of the UTP cabling system that extends from the work areas to the Equipment Room (MDF/ER) or Telecommunications Room (TR/IDF). The horizontal cabling shall be configured in a star topology, and include the horizontal cables, the mechanically terminated jacks/inserts and the faceplates in the work areas.

B. Locations of device drops are shown on T-Series drawings.

C. This section includes minimum requirements for the following:

1. Category 6a UTP Cable from ER/TR to Telecommunications Outlets.
2. Installation, Termination, and Testing Methods.

D. Related Sections include the following:

1. 270553 – Identification for Communication Systems
2. 271116 – Communications Cabinets, Racks, Frames and Enclosures
3. 271119 – Communications Termination Blocks and Patch Panels
4. 271543 – Communications Faceplates and Connectors

1.2 QUALITY ASSURANCE

A. All telecommunications equipment and cabling 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 approval of the design team and Owners Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270500 for all applicable standards and codes.

C. Strictly adhere to all Category 6a installation practices when installing UTP data cabling.

D. All connecting equipment shall be from the same manufacturer.

1.3 SUBMITTALS

A. Contractor shall provide all submittals according to Section 270500.

PART 2 - PRODUCTS

2.1 CATEGORY 6A HORIZONTAL COPPER CABLING

A. In accordance with ANSI/TIA 568C.2 all horizontal data cable shall be:

1. UL listed, 4-pair 100 ohm, UTP, minimum Category 6a compliant
2. Conductors shall be minimum of 23 AWG, solid bare annealed copper.
3. Maximum overall cable diameter shall be 0.280 inches.
4. Cable shall be insulated with FEP material.

5. Cable shall be NEC CMP rated.

B. Cable shall be sequentially marked at 2-foot intervals.

C. Cable pairs shall be color coded:

1. Pair 1- White/Blue and Blue.
2. Pair 2- White/Orange and Orange
3. Pair 3- White/Green and Green
4. Pair 4- White/Brown and Brown

D. Jacket colors shall be as follows:

1. Data – Blue
2. Video Security - Yellow
3. Wireless Access Points – Orange

E. Acceptable Manufacturers:

1. Belden
2. Berk-Tek
3. Commscope
4. General Cable
5. Hubbell
6. Mohawk Cable Corporation
7. Panduit
8. Superior Essex
9. Or Equal

PART 3 - EXECUTION

3.1 GENERAL

A. All cabling shall be installed according to ANSI/TIA specifications and BISCI standards.

B. All horizontal cabling shall be terminated on patch panels and jacks as noted above.

C. Provide a minimum of 10 feet of cable slack at both ends of the horizontal cables to accommodate future cabling system changes.

1. At the station end of the cabling run, the service loop shall be stored above the ceiling line at an accessible point and supported with an approved device designed for that purpose.
2. Within a telecommunications room, the service loop shall be stored within the ladder tray.

D. All patch panels, cables, jacks, system components, etc. shall be labeled according to ANSI/TIA-606-B specifications and in coordination with the owner and design team.

E. All horizontal cables shall be equipped with a self-laminating, wrap-around, machine printed label at both ends of the cable.

F. All patch panels shall be equipped with pre-printed, cable identification designation strips installed behind clear plastic label holders on the front of the patch panel.

G. All modular faceplates shall be equipped with a pre-printed, cable identification strip, installed behind a clear plastic label holder.

H. Painting of the structured cabling voids the warranty. Cable shall not be painted.

3.2 HORIZONTAL COPPER CABLING

A. Before the installation of Horizontal Cabling is allowed to begin, the Contractor must provide a mock-up of the labeling and wiring to a sample faceplate and patch panel.

1. The mock-ups must be reviewed by an appropriate representative of the Owner and approved prior to performing any final wiring required by the project documents.

B. Installation of Horizontal Copper Cabling

1. 4-pair UTP cables should withstand 25 foot-pounds of pulling pressure. This number shall be verified by the wire manufacturer.

a. Maximum cable length is limited to 90 meters (295 feet) from the jack to the patch panels.
b. Comply with ANSI/TIA/EIA-569 standard regarding the requirements and recommendations for separation of copper telecommunication cabling from sources of electromagnetic interference.
c. The Contractor shall replace any damaged cable at no expense to the Owner. No repair will be allowed on damaged cables.

2. Cabling shall be terminated at the station jack and at the equipment room as indicated in ANSI-TIA-EIA-568, wiring configuration T568B.

a. The modular faceplate at the user end shall be equipped with inserts for communication services as indicated on T-series drawings.
b. Station cable in the TR shall be terminated on Category 6a patch panel located in the equipment racks.
c. The minimum bend radius of 6a UTP cable shall not be smaller than four (4) times the diameter of the jacketed cable, and shall not cause the cable jacket to buckle.
d. Route cables from the back of the patch panel through its coupler openings and loosely attach them to the wire manager with Velcro cable ties, leaving enough slack for re-termination at a future date.
e. Remove only as much jacketing as needed to terminate properly to the connecting hardware, keeping the amount of jacketing removed to an absolute minimum.
f. Do not untwist pairs more than 0.5 inches.
g. Visually inspect cable pairs for bare wire and other defects before terminating wires.
h. Once all of the cables have been terminated, dress the cable slack behind the panel with Velcro tie wraps tightened to a snug but not compressing fit.

C. Testing of Horizontal Copper Cabling

1. Perform visual inspection to ensure that all cables are terminated on the eight position station jacks on both ends in proper color code order.
2. All terminated cabling runs shall be 100% tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements found in the TIA/EIA-568-C series of standards. All pairs in each installed cable shall be verified prior to system acceptance. Any defect in the cabling system installation, including (but not limited to) cables, connectors, patch panels, and cordage shall be repaired or replaced in order to ensure 100% usability of all installed runs.

3. All balanced twisted-pair cable links shall be tested for basic continuity and length, as indicated below. Of the parameters listed, it is understood that PSANEXT cannot be tested using current field test equipment.
4. Continuity – Each pair in every installed cabling run shall be tested using a test set that detects and identifies opens, shorts, polarity and pair reversals, crossed pairs, and split pairs. The results shall be recorded as Pass/Fail (as indicated by the test set) and referenced to the appropriate cable identification number and circuit/pair number. Any fault shall be corrected, and the run re-tested prior to final acceptance.
5. Length – Every installed cabling run shall be tested for installed length using a time domain reflectometer (TDR) device. The cable length shall not exceed 90m (295 ft). The cable length shall be recorded, referencing the cable identification number and circuit/pair number.
6. Category 6a performance testing shall be done according to the published standards.
7. The approved handheld tester will have the capability to be programmed with current Category 6a requirements as specified in ANSI/TIA/EIA-568 standards.
8. Documentation will include cable ID (same as jack ID) to be marked on the punch down blocks and patch panels in the telecommunication closet, station jack ID to be marked on the station jack and results of the testing done with the cable analyzer.
9. Test results shall be stored on a physical storage medium such as a CD, DVD, or thumb drive and delivered to the Owners representative.
10. Analyzer documentation will also need to be in “pdf”, “csv”, or “dat” format.

    a. Results must be labeled using the telecommunications outlet labeling scheme for the project.

11. Test results shall be verified by the designated Owners personnel as part of the inspection and acceptance procedure.

3.3 WARRANTY AND CERTIFICATION

A. System shall be certified under the selected manufacturers’ application assurance warranty. Warranty shall be by the manufacturer and contractor, for a period of at least 25 years on the horizontal cabling; including patch panels, patch cables, terminations and labor. The remaining portions of the system shall be warranted for a period of one (1) year from the date of substantial completion.

B. The manufacturer of the cable and manufacturer of the connectivity products must have an agreement in place.

END OF SECTION 271513

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes the minimum requirements for the installation, termination, and labeling of the faceplates and connectors as depicted on the Drawings and required by these specifications.

B. This section includes minimum requirements for the following:

1. Category 6a Jack Modules
2. Faceplates and Adapters
3. Surface Mount Boxes

C. Related Sections include the following:

1. 270528 - Pathways for Communications Systems
2. 270553 – Identification for Communication Systems
3. 271116 - Communications Cabinets, Racks, Frames and Enclosures
4. 271119 - Communications Termination Blocks and Patch Panels
5. 271513 - Communications Copper Horizontal Cabling

1.2 QUALITY ASSURANCE

A. All telecommunications equipment and cabling 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 approval of the design team and Owners Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based on the acceptable manufacturers listed. Where “or equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270500 for all applicable standards and codes.

1.3 SUBMITTALS

A. Contractor shall provide all submittals according to Section 270500.

PART 2 - PRODUCTS

2.1 CATEGORY 6A JACK MODULES

A. Contractor shall provide the quantity of Category 6a jacks required by the contract drawings for the project. Provide jacks in faceplates in work areas as well as MDF/ER and IDF/TR locations as needed.

B. Physical Specifications:

1. Functional from -10 degrees F to 140 degrees F
2. Tested in accordance with ANSI/TIA-568-C-2 for Category 6a.
3. Modular RJ45 keystone jacks that snap into user configurable faceplates meeting durability requirements specified in IEC 603-7.

4. IDC, RJ45 female type suitable for eight 22-26 AWG wires and be certified Category 6a compliant.
5. Wired in accordance with EIA/TIA T568B polarization sequence
6. Jack colors at the patch panel and telecommunications outlet shall be as follows:

    a. Data – Blue
    b. Video Security - Yellow
    c. Wireless Access Points – Orange

C. Panduit products are not acceptable.

D. Acceptable Manufacturers:

1. Belden
2. Commscope
3. Hubbell
4. Leviton
5. Ortronics
6. Panduit
7. Or Approved Equal

2.2 FACEPLATES AND ADAPTERS

A. The faceplate shall be a one-piece, single or dual-gang flush-mount style that fits standard NEMA openings and accommodates low-voltage box eliminators for a flush mount.

B. It shall provide 4, 6, 8, or 12 ports as required. The faceplate shall feature clear port ID windows.

C. Faceplates be made of stainless steel and be cULus Listed and compliant with ANSI/TIA-568-C.0 specifications.

D. Port counts, and configurations to be specified per schedules and details on contract drawings. Faceplate screws shall match faceplate color.

E. Contractor shall provide blanks for all unused ports in all faceplates.

F. Acceptable Manufacturers:

1. Belden
2. Commscope
3. Hubbell
4. Leviton
5. Ortronics
6. Panduit
7. Or Approved Equal

2.3 SURFACE MOUNT BOX LOCATIONS

A. Contractor shall provide surface mount boxes only as shown on the T-Series drawings. Any other locations shall be clarified with the Owner before use.

B. Surface mount boxes shall be provided in one, two, or four outlet combinations as required for telecom outlet terminations. Provide boxes as required to fully cover and protect all telecommunications terminations.

C. Boxes shall be plenum rated as required and mounted the manufacturer supplied in-ceiling support bracket for above ceiling installation.

D. Panduit products are not acceptable.

E. Acceptable Manufacturers:

1. Belden
2. Commscope
3. Hubbell
4. Leviton
5. Ortronics
6. Panduit
7. Or Approved Equal

PART 3 - EXECUTION

3.1 GENERAL

A. All cables shall be terminated with high density modular jacks that snap into a faceplate mounted on a wall outlet box or surface raceways.

B. Outlet boxes shall be secured to the building with mechanical fasteners. Adhesive fasteners are not allowed.

C. All openings not used shall be filled with appropriate blank inserts.

D. All locations shall be labeled as to its purpose and/or destination. Confirm labeling with design team and Owner before final installation.

3.2 FACEPLATES

A. Contractors shall provide and install all telecommunications faceplates, adaptors, and connectors as required to terminate all cabling.

3.3 TELECOMMUNICATIONS OUTLET ROUGH-IN

A. Standard Telecommunications Outlets (single gang or double gang) shall be located at the same height as 120-volt AC outlets (normally 18 inches above finished floor).

B. No Telecommunications Outlet location shall be installed more than 6 inches from the nearest designated 120-volt outlet serving that location.

C. Telecommunications Outlets above countertops should be installed so that the center of the outlet box will be a minimum of 12 inches above the countertop.

1. A countertop with a backsplash may require different outlet box locations.

D. No Telecommunications work area outlet will be installed such that workstations or devices served from it cannot be reasonably reached by a 15 foot patch cable.

3.4 LABELING

A. Contractor shall complete labeling according to section 270553.

END OF SECTION 271543

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section includes the minimum requirements for the installation, configuration, and training of the audio-visual components as depicted on the Drawings and required by these specifications.

B. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether specified or shown on the drawings or not.

C. All required cabling infrastructure including back boxes and conduit to support the AV systems are provided and installed by others. Contractor is required to provide, install, test, and configure all cabling, equipment, and AV systems as described within this specification and as shown on the T-series drawings.

D. This section includes minimum requirements for the following:

1. AUDIO RELAY
2. AV DECODER
3. AV ENCODER TYPE 1
4. AV ENCODER TYPE 2
5. AV EQUIPMENT RACK TYPE 1
6. AV EQUIPMENT RACK TYPE 2
7. AV NETWORK SWITCH
8. CLASSROOM AV TRANSMITTER
9. DIGITAL SIGNAL PROCESSOR TYPE 1
10. EQUIPMENT RACK BLANKS
11. EQUIPMENT RACK VENTS
12. EQUIPMENT RACK SHELVES
13. EQUIPMENT RACK DRAWERS
14. FLAT PANEL DISPLAY
15. LAT PANEL DISPLAY WALL MOUNT
16. FLAT PANEL DISPLAY CEILING MOUNT
17. HEARING ASSISTANCE SYSTEM
18. INTERACTIVE FLAT PANEL DISPLAY
19. LAPTOP
20. LOUDSPEAKER TYPE 1
21. LOUDSPEAKER TYPE 2
22. LOUDSPEAKER TYPE 3
23. LOUDSPEAKER TYPE 4
24. SPEAKER RIGGING COMPONENTS
25. MEDIA PLAYER
26. MIC/LINE INTERFACE

27. POWER AMPLIFIER TYPE 1
28. POWER AMPLIFIER TYPE 2
29. POWER AMPLIFIER TYPE 4
30. POWER SEQUENCING SYSTEM
31. QUAD MONITOR ADAPTOR
32. STEREO TO MONO ADAPTOR
33. TOUCH PANEL
34. WIRELESS MICROPHONE ANTENNA DISTRIBUTION
35. WIRELESS MICROPHONE SYSTEM

1.2 QUALITY ASSURANCE

A. The following industry Standards are the basis for the audio-visual system described herein. The list is incorporated by this reference to them.

1. ANSI - American National Safety Institute
2. ASTM - American Society of Testing and Materials
3. EIA - Electronics Industries Association
4. FCC - Federal Communications Commission
5. NEMA - National Electrical Manufacturer's Association
6. OSHA - Occupational Safety and Health Administration
7. NEC - National Electric Code.
8. NFPA - National Fire Protection Association.
9. IEEE - Institute of Electrical and Electronics Engineers.
10. ISO - International Standards Organization.
11. UL - Underwriters Laboratories
12. Davis and Davis, Sound System Engineering (2nd Edition), Howard W. Sams, 1987
13. Giddings, Audio System Design and Installation (ASDI), Howard W. Sams, 1990

B. 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 Design 27 Project Manager. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction.

D. Contractor should have the following qualifications:

1. Experienced in the installation of systems similar in complexity and scale to those included within the scope of work. If requested, the Contractor shall provide the names, locations, and points of contact for at least three installations of the type and complexity specified herein.

2. Within the last two (2) years, installed an audio-visual system with similar equipment and functionality.
3. Have at least one (1) person on staff with CTS-I certification.

1.3 SUBMITTALS

A. As part of this specification section, Contractor shall be responsible for providing the following submittals.

1. Manufacturer Product Data
2. Pre-Installation Shop Drawings
3. User Interface Submittal
4. As-Built Drawings
5. Configuration files and Source Code

B. Manufacturer Product Data - The Contractor shall provide manufacturers' catalog sheets, specifications, and installation instructions for all products to be installed within the scope of work. This is to verify that the submitted components comply with the Contract Documents. Submittals shall be formatted as follows.

1. Submit only products that appear in this section or that are required for a complete installation relating to the products in this section. Submission of products from multiple sections will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.
2. Each product intended to be used shall be included one time only. Do not submit similar products multiple times.
3. Submittal shall include an index with page(s) listed in order of specification within corresponding section, with subsection number and generic name correlated to product submitted. Sheet index and/or product data sheets organized alphabetically, randomly or in any manner which does not match the specification order will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.
4. Following index sheet, include Manufacturer specification sheet stapled in order of properly organized index.

    a. Where multiple products exist on a single sheet, Contractor shall clearly indicate whether with highlight, arrow, PDF stamp, etc. the product intending to be used.
    b. Failure to indicate specific product to be used will be cause for marking submittal Revise and Resubmit.

C. Pre-Installation Shop Drawings – Prior to the start of field work the Contractor shall provide pre-installation shop drawings noting the intended installation means and methods for this scope of work. This is to ensure the Contractor understands the scope of work and to provide the field installation teams with all information necessary for successful implementation.

1. Drawings shall be created using modeling software, such as Autodesk AutoCAD. In addition, they shall be exported in PDF format for review by the designer and Owner.

2. Drawings shall contain floor plans, RCPs (if applicable), section views, and details illustrating equipment location, including but not limited equipment racks, IR amplifiers, projection screens, connection panels, flat panel displays, and loudspeakers. Drawings shall be at no less than 1/8"=1'-0" scale.
3. Detailed wiring diagrams showing the interconnection between equipment devices. This shall include cable labeling, cable types, connector types and termination details, wiring color codes, and equipment manufacturer and models. Note cabling provided by Others. Diagrams included as part of Construction Documents are included to convey design intent and are not acceptable for use in Pre-Installation Shop Drawings and will be cause for rejection.
4. Loudspeaker, video projector, projector lift, and projection screen mounting details, including hardware type, material, and load capacity. For all equipment mounted overhead, mounting details and design calculations shall be signed and sealed by a professional structural engineer currently licensed to practice in the State of the work to be performed. The details included in the Construction Documents are included to convey design intent and are not acceptable for use in Pre-Installation Shop Drawings and will be cause for rejection.
5. Dimensioned plate and panel details that are custom for the project. Details shall include dimensioned locations of components, component type, engraving information, bill of materials, and plate finish and color. If custom part numbers are generated by a manufacturer, they shall be included on the plate details.
6. Rack elevations showing equipment layout within racks with dimensions. The Contractor shall allocate space in the rack for all equipment that will ultimately be installed within, including all Owner Furnished equipment where applicable.
7. Wiring schedule showing the source and destination of wiring and indicating whether the wire is in conduit or cable tray.

D. User Interface Submittals – The Contractor shall provide user interface submittals to convey the look and feel of user interfaces along with intended functionality. This is to ensure the Contractor understands the scope of work and to streamline the programming process prior to field installation.

1. Submit within 14 days of Pre-Installation Shop Drawing submittal.
2. Submit individual PDF files with screenshots of touch panels to be configured for the project.

    a. In text below screenshot, describe what pressing each button will accomplish in the program.
    b. Include both what users would experience in the room as well as on the touch panel. Ex. “Pressing Power On will turn on projector, lower projector screen and take users to the [SOURCES] page of touch panel.
    c. Where identical buttons exist on multiple pages, describe their function only once.

3. If button panels with user replaceable or custom buttons are included in project scope, submit PDF screenshot of proposed button configuration.

a. In text below screenshot, describe what pressing each button will accomplish in the program.

E. As-Built Drawings - The Contractor shall provide Final documentation noting the actual installed conditions for this scope of work. This is to provide the Owner with accurate historical data of the project for future reference. As-Built Drawings shall be submitted during project close-out for inclusion in the O&M manual. Submittals shall be formatted as follows.

1. Submit one (1) PDF set of redlined Contractor generated As-Built Drawings. The Owner reserves the right to request an electronic copy of the shop drawings in both Autodesk CAD (.DWG) format and PDF format.
2. As-Built Drawings that utilize the Contract Documents as a base, shall be inclusive of all Published Addendums, ASIs, Accepted PCOs, PRs, SIs, etc. Changes made via RFI or Field Directive that were not published changes to the Contract Drawings shall be noted as such on the As-Builts with the noted RFI or FD #.
3. All text notes included on As-Builts shall be easily legible on PDF. Handwritten notes that are not legible shall be replaced with PDF text.
4. Include equipment manufacturer/model as installed in the field.
5. Include revised functional diagrams based on those submitted and approved during the Pre-Installation Shop Drawing submittal.

F. Configuration Files and Source Code – The Contractor shall provide the final equipment configuration files and Source Code installed on the project. These files shall be submitted concurrently with As-Built Drawings.

1. Include configuration files for all equipment, including but not limited to, digital signal processors, video switchers, control processors, amplifiers, etc. Owner notes that any changes made during the warranty period not completed by the Contractor will void the system warranty.
2. Include any passwords that may have been created that are required to access equipment. Owner notes that any changes made during the warranty period not completed by the Contractor will void the system warranty.
3. Contractor is not required to provide manufacturer software used for configuration.

    a. Include any control processor source code in its uncompiled format. Owner notes that any changes made during the warranty period not completed by the Contractor will void the system warranty.

1.4 CLOSE-OUT DOCUMENTS

A. Provide close-out documents in accordance with the General Conditions unless otherwise indicated:

1. Provide the following for products incorporated into the final installation:

a. Manufacturer's data for each type of product. Include manufacturer's serial numbers within the list of product.
b. Each products Owner/Instruction Manual. Provide high quality copies where necessary, with legible text and illustrations of equal resolution and sharpness as the original manual. Faxed copies or copies with portions of the information missing or smeared are not acceptable.

2. Provide as-built drawings depicting what is incorporated within the project delivered as electronic files. All text within drawings shall be legible.
3. Provide recorded test reports of Contractor commissioning.
4. Prepare and provide a complete and typical procedure for the operation of the equipment as a system including:

a. Describe the operation of system capabilities.
b. Assume the intended reader of the manual to be technically inexperienced and unfamiliar with this facility.

5. Any other pertinent data generated during the project or required for future service.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Equipment and components shall arrive onsite properly protected and undamaged with containers, packaging and labels intact.

B. Store, handle and protect materials and equipment in accordance with Manufacturer's recommendations.

C. Store materials and equipment in dry, environmentally controlled space. Do not install equipment and materials until spaces are enclosed, watertight, and dry. Protect equipment from dust and other airborne materials.

D. Provide additional protection during handling as necessary to prevent breaking, scraping, marring, or otherwise damaging products or surrounding areas.

E. Protect all equipment and components that are to be installed within this project from theft, vandalism, and exposure to rain, freezing temperatures and direct sunlight.

F. Protect installed equipment and components from damage and prevent use by unauthorized persons.

1.6 WARRANTY

A. The Contractor shall warrantee the completed work for a period of one (1) year, from the date of acceptance of the work, to be free of defect in design, workmanship, or material.

B. Contractor shall repair, adjust, and/or replace, whichever the Owner determines to be in its best interests, any defective equipment, materials, or workmanship, as well as such parts of the work

damaged or destroyed by such defect, during the warranty period, at the Contractor's sole cost and expense. If parts or components need to be repaired, then a loaner will be supplied and installed until the part or component can be repaired and reinstalled.

C. All service work shall be performed by manufacturer-certified technicians.

D. Contractor to provide Owner a phone number for technical support. All support calls shall be answered within twenty-four (24) hours. All repairs shall be underway within forty-eight (48) hours and completed (or loaner supplied) within seven (7) days.

E. At the end of the warranty period, the Contractor shall complete one (1) site visit to evaluate the status of the audio-visual systems. All equipment within this scope of work found to be defective shall be replaced at no cost to the Owner.

F. As part of the site visit, the Contractor shall move each TEACHER STATION/CLASSROOM AV TRANSMITTER from the current location FRONT or BACK of the classroom to the alternate location at no additional cost to the Owner. This is a one-time service to be included at the Owner's request.

G. Guarantees of material, equipment, and workmanship running in favor of the Contractor shall be transferred and assigned to the Owner on completion of the work and acceptance of said work by the Owner.

PART 2 - PRODUCTS

2.1 AUDIO RELAY

A. Shall meet or exceed the following specifications:

1. Shall be capable of accepting line level audio input sources.
2. Shall have input sensitivity of -30 dBu to 0 dBu adjustable.
3. Shall have an adjustable, nominal release delay of 0.5 to 5.0 seconds.
4. Shall have an integrated LED indicating audio threshold for the adjustment of input sensitivity.
5. Shall be rated for a maximum switching current of 2A
6. Include manufacturer recommended power supply by same manufacturer.
7. Acceptable Manufacturers:

    a. RDL ST-ACR1
    b. Or Equal

2.2 AV DECODER

A. Shall meet or exceed the following specifications:

1. Shall be capable of transmitting audio, video, and control over one (1) STP cable.

2. Shall have a minimum of one (1) HDMI output.
3. Shall have a minimum of one (1) LAN port.
4. Shall support power over ethernet (PoE) IEEE 802.3af.
5. Shall support AES67 audio codec
6. Shall support resolutions up to and including 3840 x 2160p or higher.
7. Shall be HDCP and AES compliant.
8. Coordinate color with architect prior to procurement.
9. Acceptable Manufacturers:

    a. Visionary Solutions D5100
    b. Or Equal

2.3 AV ENCODER TYPE 1

A. Shall meet or exceed the following specifications:

1. Shall be capable of transmitting audio, video, and control over one (1) STP cable.
2. Shall have a minimum of one (1) HDMI input.
3. Shall have a minimum of one (1) LAN port.
4. Shall support power over ethernet (PoE) IEEE 802.3af.
5. Shall have one (1) Bluetooth stereo audio input (A2DP)
6. Shall support AES67 audio codec.
7. Shall support resolutions up to and including 3840 x 2160p or higher.
8. Shall be HDCP and AES compliant.
9. Shall be two-gang decora.
10. Coordinate color with architect prior to procurement.
11. Acceptable Manufacturers:

    a. Visionary Solutions E5-WP-BT
    b. Or Equal

2.4 AV ENCODER TYPE 2

A. Shall meet or exceed the following specifications:

1. Shall be capable of transmitting audio, video, and control over one (1) STP cable.
2. Shall have a minimum of one (1) HDMI input.
3. Shall have a minimum of one (1) LAN port.
4. Shall support power over ethernet (PoE) IEEE 802.3af.
5. Shall support AES67 audio codec.
6. Shall support resolutions up to and including 3840 x 2160p or higher.
7. Shall be HDCP and AES compliant.
8. Coordinate color with architect prior to procurement.
9. Acceptable Manufacturers:

    a. Visionary Solutions E5100

b. Or Equal

2.5 AV EQUIPMENT RACK TYPE 1

A. Shall meet or exceed the following specifications:

1. Shall have 18 units of available rack space.
2. Shall have 16-gauge steel construction with black textured powder coat finish.
3. Minimum overall height of 35.63” with a minimum open rack mounting space of 31.63”
4. Shall have an overall depth of 25” and useable depth of 23.47”.
5. Shall have locking, vented rear door, side panels, and fans.
6. Ensure that no equipment or cabling protrudes from the front of the rack in a way that would prohibit the addition of a rack front door in the future.
7. Shall be installed inside casework with a service loop allowing the rack to be pulled out and serviced.
8. Ensure that devices with cooling fans are drawing cool air from room and exhausting hot air out the top of the rack. Provide accessories as required to ensure hot air from equipment is not recirculated into equipment cooling intakes.
9. Coordinate with casework contractor to ensure adequate ventilation.
10. Acceptable Manufacturers:

    a. Middle Atlantic ERK-1825
    b. Or Equal

2.6 AV EQUIPMENT RACK TYPE 2

A. Shall meet or exceed the following specifications:

1. Shall have 35 units of available rack space.
2. Shall have 16-gauge steel construction with black textured powder coat finish.
3. Shall have locking, vented doors, side panels, and fans.
4. Ensure that no equipment or cabling protrudes from the front of the rack in a way that would prohibit the addition of a rack front door in the future.
5. Shall have an overall depth of 22” and useable depth of 20”.
6. Shall be constructed to swing open for cabling access.
7. Shall have a large 12.5” x 12.5” knockout at the rear along with additional knockouts in the sides of the racks.
8. Ensure that devices with cooling fans are drawing cool air from room and exhausting hot air out the top of the rack. Provide accessories as required to ensure hot air from equipment is not recirculated into equipment cooling intakes.
9. Acceptable Manufacturers:

    a. Middle Atlantic DWR-35-22
    b. Or Equal

2.7 AV NETWORK SWITCH

A. Shall meet or exceed the following specifications:

1. Shall have a minimum of 24 gigabit ports.
2. Shall have a minimum of 300 watts of PoE budget available.
3. Shall have integrated 10Gb copper uplink ports, or support 10Gb copper uplinks via SFP. If using SFP, Contractor shall provide quantity of modules as required to support connectivity shown on T-Series drawings.
4. Shall support communication over Layer 2 at a minimum.
5. Shall support DANTE digital audio communication protocol.
6. Shall be capable of supporting AVB communication protocol.
7. Shall be capable of supporting future AVoIP communication protocols.
8. Acceptable Manufacturers:

    a. Netgear M4250
    b. Or Equal

2.8 CLASSROOM AV TRANSMITTER

A. Shall meet or exceed the following specifications:

1. Shall support HDMI 2.0, HDCP 2.2 / HDCP 1.4
2. Shall support resolutions up to 2160p 60Hz (4K-18G)
3. Shall support HDBaseT over a single Cat6a cable up to 230ft distance at 1080p or 132ft distance at 4K 60Hz
4. Shall support USB 2.0
5. Shall support HDR and CEC pass-through.
6. Provide rough-in with CAT 6a cable at back of each room as depicted in T-Series drawings
7. Clearly label cabling “FRONT” or “BACK” per drawings and labelling specifications.
8. Provide specific owner training concerning the relocation of the wall plate transmitter from the FRONT to the BACK location and how to swap the cables at the receiver location to accommodate the BACK location of teacher desk.
9. See section WARRANTY 1.6 E for additional information.
10. Acceptable Manufacturers:

    a. COVID EHB-250-W
    b. Or Equal

2.9 DIGITAL SIGNAL PROCESSOR TYPE 1

A. Shall meet or exceed the following specifications:

1. Shall have a minimum of eight (8) balanced flex channels (input or output) with AEC.
2. Shall provide an open architecture for signal routing.

3. Shall be capable of routing up to 64 networked audio channels over Q-LAN or AES67.
4. Shall support a minimum of 8x8 channels of Dante audio routing.
5. Shall have a maximum input level of +24dBu and maximum output level of +20 dBU.
6. Shall have a minimum dynamic range of 108dB, 20Hz – 20000Hz.
7. Control software to include, but not limited to: matrix mixers, limiters, gain adjustment, delay, parametric equalizers, crossovers, and compressors.
8. Acceptable Manufacturers:

    a. QSYS Core 8 Flex
    b. Or Equal

2.10 EQUIPMENT RACK BLANKS

A. Contractor to provide equipment rack blanks as required by the T-series drawings.

B. Shall meet or exceed the following specifications:

1. Shall have a flanged construction.
2. Shall be made of 1/16” thick aluminum.
3. Shall have a black brushed and anodized finish.
4. Provide quantity and sizes as required by the T-series drawings.
5. Acceptable Manufacturers:

    a. Middle Atlantic BL Series
    b. Or Equal

2.11 EQUIPMENT RACK VENTS

A. Contractor to provide equipment rack vents as required by the T-series drawings.

B. Equipment rack vents shall meet or exceed the following specifications:

1. Shall have a flanged construction.
2. Shall be made of 1/16” thick aluminum.
3. Shall have a black brushed and anodized finish.
4. Provide quantity and sizes as required by the T-series drawings.
5. Acceptable Manufacturers:

    a. Middle Atlantic VTP Series
    b. Or Equal

2.12 EQUIPMENT RACK SHELVES

A. Contractor to provide equipment rack shelves as required by the T-series drawings.

B. Equipment rack shelves shall meet or exceed the following specifications:

1. Shall have a flanged construction.
2. Shall have 16-gauge steel construction with black textured powder coat finish.
3. Shall have a minimum load capacity of 50 pounds.
4. Provide quantity and sizes as required by the T-series drawings.
5. Acceptable Manufacturers:

    a. Middle Atlantic U Series
    b. Or Equal

2.13 EQUIPMENT RACK DRAWERS

A. Contractor to provide equipment rack drawers as required by the T-series drawings.

B. Equipment rack drawers shall meet or exceed the following specifications:

1. Shall have a flanged construction.
2. Shall have 16-gauge steel construction with black textured powder coat finish.
3. Shall have a minimum load capacity of 50 pounds.
4. Shall include grommeted cable pass-through in rear of drawer.
5. Provide quantity and sizes as required by the T-series drawings.
6. Acceptable Manufacturers:

    a. Middle Atlantic UD Series
    b. Or Equal

2.14 FLAT PANEL DISPLAY

A. Shall meet or exceed the following specifications:

1. Shall support resolutions up to and including 3840x2160p, 60 Hz.
2. Shall be LED Backlit.
3. Shall have a minimum contrast ratio of 5000:1.
4. Shall have a minimum brightness of 350 cd/m^2
5. Shall be RS-232 controllable.
6. Shall be commercial grade. Consumer grade displays are not acceptable.
7. Shall have integrated smart TV app compatibility (i.e. youtube app).
8. “MON” (Monitor locations within the T-series drawings) displays shall be 18/5 rated.
9. “DS” (Digital Signage locations within the T-series drawings) displays shall be 24/7 rated.
10. Reference T-series drawings for display sizes.
11. Reference AV diagrams for locations where panels are to be installed.
12. Acceptable Manufacturers:

    a. Samsung
    b. LG
    c. Sony

d. Panasonic
e. Or equal

2.15 FLAT PANEL DISPLAY WALL MOUNT

A. Shall meet or exceed the following specifications:

1. Shall support weight of associated display.
2. Shall be non-articulating mount.
3. Shall have an adjustable tilt of -5 or +20 degrees.
4. Shall provide access to backbox without removing mount.
5. Mount shall be selected to ensure total depth of flat panel display and mount does not exceed 4” from the wall.
6. Provide all mounting hardware and accessories as required by the T-series drawings and manufacturer recommendations.
7. Acceptable Manufacturers:

a. Chief
b. Peerless-AV
c. AvTeq
d. Or equal

2.16 FLAT PANEL DISPLAY CEILING MOUNT

A. Shall meet or exceed the following specifications:

1. Shall support weight of associated display.
2. Shall fit display mounting patterns up to 600 x 400mm.
3. Provide fixed extension columns as required by the T-series AV elevations. Confirm final mounting height with architect prior to procurement.
4. Shall have an adjustable tilt of -5 to +20 degrees.
5. Shall have 360-degree swivel
6. Provide all mounting hardware and accessories as required by the T-series drawings and manufacturer recommendations.
7. Acceptable Manufacturers:

a. Chief
b. Peerless-AV
c. AvTeq
d. Or equal

2.17 HEARING ASSSITANCE SYSTEM

A. Shall meet or exceed the following specifications:

1. Shall have a minimum of one (1) balanced mono XLR audio input and one (1) unbalanced stereo RCA input.
2. Shall have an internal audio compressor.
3. Shall have an operating frequency of 216MHz.
4. Shall have a maximum output power of 100mW.
5. Provide remote antennas as shown on the T-series drawings.
6. Provide quantity and type of receivers to meet ADA requirements.
7. Provide charging carrying case to accommodate all receivers.
8. Provide rechargeable lithium-ion batteries to accommodate all receivers.
9. Acceptable Manufacturers:

    a. Listen Tech LT-800-216 (as shown on T-series AV diagrams)
    b. Listen Tech LA-122 (as shown on T-series drawings)
    c. Listen Tech LR-4200-216 (Quantity: 8 per transmitter)
    d. Listen Tech LA-164 (Quantity: 8 per transmitter)
    e. Listen Tech LA-165 (Quantity: 8 per transmitter)
    f. Listen Tech LA-438 (Quantity: 8 per transmitter)
    g. Listen Tech LA-380 (Quantity: 1)
    h. Listen Tech LA-365 (Quantity: 8 per transmitter)
    i. Or equal

2.18 INTERACTIVE FLAT PANEL DISPLAY

A. Shall meet or exceed the following specifications:

1. Shall support resolutions up to and including 3840x2160p, 60 Hz.
2. Shall be LED Backlit.
3. Shall have a minimum contrast ratio of 5000:1.
4. Shall have a minimum brightness of 350 cd/m^2
5. Shall have manufacturer optional wireless connectivity.
6. Shall be commercial grade. Consumer grade displays are not acceptable.
7. Reference T-series drawings for display sizes.
8. Reference AV diagrams for locations where panels are to be installed.
9. Acceptable Manufacturers:

    a. Clevertouch Pro Series 3 with Clevershare

2.19 LAPTOP

A. Shall meet or exceed the following specifications:

1. Shall be capable of being powered by no more than 130 Watt USB-C connection
2. Shall be capable of driving four (4) DisplayLink capable display devices.
3. Shall have a minimum of sixteen (16) GB RAM
4. Shall have Intel 10th Generation or later processor.

5. Shall have integrated or discreet Intel HD 4000, ATI Radeon HD8650, Nvidia GeForce 7xxM GPU or better.
6. Shall have minimum Intel Core i7
7. Minimum 2GHz processor with SSE2
8. Shall be provided with Windows license and be capable of joining school district domain.
9. Acceptable Manufacturers:

    a. Lenovo 14” ThinkPad T14 Gen 5
    b. Dell Latitude 7450 14” FHD+ 2 in 1
    c. Dell 13.4” XPS 13 9340
    d. Or equal

2.20 LOUDSPEAKER TYPE 1

A. Shall meet or exceed the following specifications:

1. Shall be ceiling mounted.
2. Shall be a two-way configuration with an 8” LF driver and 1.25” HF driver.
3. Shall have a coverage pattern of 115º conical.
4. Shall have a nominal continuous power handling of no less than 175W.
5. Shall have a sensitivity of no less than 94dB.
6. Shall have a frequency response of 75Hz – 20000Hz ±10dB.
7. Shall have 70V tap. Tap loudspeaker as shown on T-series drawings.
8. Provide all necessary hardware and brackets required for installation.
9. Verify color with Architect.
10. Acceptable Manufacturers:

    a. Biamp DX-IC8
    b. Or equal

2.21 LOUDSPEAKER TYPE 2

A. Shall meet or exceed the following specifications:

1. Shall be ceiling mounted.
2. Shall be a two-way configuration with an 10” LF driver and 1.25” HF driver.
3. Shall have a coverage pattern of 115º conical.
4. Shall have a nominal continuous power handling of no less than 240W.
5. Shall have a sensitivity of no less than 96dB.
6. Shall have a frequency response of 65Hz – 20000Hz ±10dB.
7. Shall have 70V tap. Tap loudspeaker as shown on T-series drawings.
8. Provide all necessary hardware and brackets required for installation.
9. Verify color with Architect.
10. Acceptable Manufacturers:

    a. Biamp DX-IC10

b. Or equal

2.22 LOUDSPEAKER TYPE 3

A. Shall meet or exceed the following specifications:

1. Shall be a two-way coaxial configuration with a 12” LF driver and a 1” HF driver.
2. Shall have a coverage pattern of 90º H x 90º V.
3. Shall have a power rating of no less than 200W.
4. Shall have a sensitivity of no less than 103dB.
5. Shall have a frequency response of 85Hz – 21800Hz
6. Provide all necessary hardware and brackets required for installation.
7. Acceptable Manufacturers:

    a. Biamp Community R.5 99Z
    b. Or equal

2.23 LOUDSPEAKER TYPE 4

A. Shall meet or exceed the following specifications:

1. Shall be a 3-way, full range design.
2. Shall be a minimum 12” coaxial loudspeaker.
3. Shall have a coverage pattern of 90ºx60º Horiz. X Vertical pattern.
4. Shall have nominal continuous power handling of no less than 400W at 8 ohms.
5. Shall have a sensitivity of no less than 98dB.
6. Shall have a frequency response of 80Hz – 16000Hz
7. Provide all necessary hardware and brackets required for installation.
8. Confirm final color and finish with Architect.
9. Acceptable Manufacturers:

    a. Biamp Community R.35-3896
    b. Or equal

2.24 SPEAKER RIGGING COMPONENTS

A. Contractor shall provide and install speaker rigging components as necessary to mount main loudspeakers as shown on the T-series drawings.

B. Structural support members to have a safety factor of at least 5. Mounting hardware and wire rope to have a safety factor of 8. All fasteners to be graded and certified for use in the intended applications. Overhead suspension hardware shall comply with ASME B30.20 standards and all applicable local building and safety codes.

C. Overhead suspension hardware must be of a type that includes product traceability controls.

D. Rigging, mounting and support systems for loudspeakers shall be designed and sealed by a registered professional engineer licensed to practice in the State of Indiana. Once the systems are installed, the engineer shall physically inspect the methods and means used to verify compliance with the original design.

E. Loudspeaker Rigging Components shall meet or exceed the following specifications:

1. Loudspeaker Rigging Components shall be made of quenched or tempered forged steel.
2. Loudspeaker Rigging Components shall meet or exceed all the requirements of ASME B30.26 including identification, ductility, design factor, proof load and temperature requirements
3. Loudspeaker Rigging Components shall be hot dip galvanized or self-colored.
4. Shackles shall meet the performance requirements of Federal Specification RR-C-271D Type IVA, Grade A, Class1.
5. Turnbuckles shall meet the performance requirements of Federal Specifications FF-T-791b, Type 1 Form 1 - CLASS 4, and ASTM F-1145.
6. Wire rope thimble shall meet the performance requirements of Federal Specification FF-T-276b Type II.
7. Wire rope shall be sized as 7x19 utility cable.
8. Provide all screw pin type shackles with mouse wire.
9. All end fittings shall be moused to the body with mousing cable.
10. Select size of product based working load limits required.
11. Confirm final product selection with architect.
12. Acceptable product:

    a. Chicago Hardware Company
    b. Crosby Group
    c. Wire Rope Corporation of America (WRCA)
    d. Or Equal
    e.

2.25 MEDIA PLAYER

A. Shall meet or exceed the following specifications:

1. Shall be capable of playing media from CD, SD, USB
2. Shall include Bluetooth® receiver.
3. Shall have one (1) 3.5mm line level input.
4. Shall be controllable via RS-232 and/or network control commands.
5. Shall have stereo balanced and unbalanced outputs.
6. Acceptable Manufacturers:
    a. TASCAM CD-400U
    b. Or Equal

2.26 MIC/LINE INTERFACE

A. Shall meet or exceed the following specifications:

1. Shall have one (1) XLR-F input.
2. Shall have one (1) 3.5mm line level input.
3. Shall transmit audio digitally over network via Category cable.
4. Shall be powered via PoE by connected network switch.
5. Shall be one-gang decora form factor.
6. Confirm color with Architect.
7. Acceptable Manufacturers:
   a. RDL D-RN2ML
   b. Or Equal

2.27 POWER AMPLIFIER TYPE 1

A. Shall meet or exceed the following specifications:

1. Power Amplifier shall have a continuous power rating of a minimum of 60 watts into 70V load.
2. Power Amplifier shall provide protection of circuit components in the event of over-drive, output overload, or short circuits.
3. Power Amplifier shall have a maximum of 0.1% THD from 80Hz – 20000Hz.
4. Power Amplifier shall have a signal to noise ratio of at least 90dB.
5. Provide with compatible volume control by same manufacturer such as Extron VC 50.
6. Acceptable Manufacturers:

   a. Extron MPA 601
   b. Or Equal

2.28 POWER AMPLIFIER TYPE 2

A. Shall meet or exceed the following specifications:

1. Shall have a continuous power rating of a minimum of 700 watts into 4 ohm, 8 ohm or 70 volt load per channel.
2. Shall provide four channels of amplification.
3. Shall provide protection of circuit components in the event of over-drive, output overload, or short circuits.
4. Shall have built-in DSP.
5. Shall have a maximum of 0.1% THD from 20Hz – 20000Hz.
6. Shall have a signal to noise ratio of at least 105dB.
7. Shall have a maximum input level of +20dBu.
8. Acceptable Manufacturers:

   a. LEA 704

b. Or Equal

2.29 POWER AMPLIFIER TYPE 3

A. Shall meet or exceed the following specifications:

1. Shall have a continuous power rating of a minimum of 700 watts into 4 ohm, 8 ohm or 70 volt load per channel.
2. Shall provide two channels of amplification.
3. Shall provide protection of circuit components in the event of over-drive, output overload, or short circuits.
4. Shall have built-in DSP.
5. Shall have a maximum of 0.1% THD from 20Hz – 20000Hz.
6. Shall have a signal to noise ratio of at least 105dB.
7. Shall have a maximum input level of +20dBu.
8. Acceptable Manufacturers:

a. LEA 702
b. Or equal

2.30 POWER SEQUENCING SYSTEM

A. Contractor to provide and install rack mounted power sequencing system for the AV equipment rack.

B. In addition to the sequencing device, provide vertical power strips as required to support the equipment and accessories.

C. Contractor to ensure all equipment is powered in the correct order to avoid audible pops and clicks from the audio-video system in response to power sequencing.

D. Rack mounted power sequencing system shall meet or exceed the following specifications:

1. Shall include a sequencer with a minimum of six (6) sequenced outlets
2. Shall include a minimum of two (2) 5-20R outlets.
3. Shall include a contact closure input.
4. Shall allow for adjustable start delay times.
5. Acceptable Manufacturers:

a. SurgeX SEQ-1U
b. Middle Atlantic PD-815SC
c. Or Equal

2.31 QUAD MONITOR ADAPTOR

A. Shall meet the following specifications:

1. Shall have ethernet monitoring and control.
2. Shall have minimum three (3) year manufacturer warranty.
3. Shall be USB powered
4. Shall support up to 4K60 display devices.
5. Shall be capable of minimum 140 Watt passthrough.
6. Provide minimum 140 Watt USB-C power source.
7. Acceptable Manufacturers:

    a. StarTech QUAD-USB-HDMI-ADAPT
    b. Or Equal

2.32 STEREO TO MONO ADAPTOR

A. Shall meet the following specifications:

1. Shall have ethernet monitoring and control.
2. Acceptable Manufacturers:

    a. RDL TX-J2
    b. Or Equal

2.33 TOUCH PANEL

A. Shall meet the following specifications:

1. Shall have ethernet monitoring and control.
2. Shall have a capacitive touch screen interface.
3. Shall have a resolution of 1920x1200.
4. Shall be 10.1” diagonal.
5. Shall have a contrast ratio of 800:1
6. Provide all necessary hardware and brackets required for installation as shown on the T-series drawings.
7. Provide TSC-101t-G3 in weight room. Provide rack mount panel in Gymnasium.
8. Confirm color with architect.
9. Acceptable Manufacturers:

    a. Q-SYS TSC-101-G3

2.34 WIRELESS MICROPHONE ANTENNA DISTRIBUTION SYSTEM

A. Shall meet or exceed the following specifications:

1. Shall operate in the 470 MHz to 690 MHz radio frequency range
2. Shall have a minimum of one (1) BNC RF input per channel
3. Shall have a minimum of four (4) BNC RF outputs per channel
4. Shall have a minimum of four (4) DC power outputs for compatible wireless audio receivers
5. All BNC RF outputs and inputs shall have 50 ohm impedance
6. Shall have a metal housing.
7. Provide necessary adapters and accessories as required. Refer to the T-series AV diagrams for more information.
8. Acceptable Manufacturers:

    a. Shure UA844+SWB/LC
    b. Shure UA834WB in-line antenna amplifier
    c. Shure UABIAST in-line power adapter
    d. Shure UA221 passive antenna splitter
    e. Shure UA8 1/2 wave dipole antenna for applications in which line of sight distances from transmitter to antenna are under 100 feet (Provide quantity shown on T-series AV diagrams)
    f. Shure UA874US active directional antenna for applications in which line of sight distances from transmitter to antenna are over 100 feet (Provide quantity shown on T-series AV diagrams)
    g. Or equal

2.35 WIRELESS MICROPHONE SYSTEM

A. Shall meet or exceed the following specifications:

1. Shall utilize a 64 MHz bandwidth
2. Shall provide digital predictive switching for true diversity.
3. Shall have up to 60 frequency presets available.
4. Shall provide automatic frequency scanning.
5. Transmitters and receivers shall utilize a metal housing.
6. Coordinate operating frequency with local RF environment.
7. Acceptable Manufacturers:

    a. Shure QLXD4
    b. Shure QLXD2/SM58 (Quantity: 1 per receiver)
    c. Shure QLXD1 (Quantity: 1 per receiver)
    d. Shure WL183M (Quantity: 1 per receiver)
    e. Shure WH20 (Quantity: 1 per receiver)
    f. Shure SB900B Rechargeable Battery (Quantity: 1 per transmitter)
    g. Shure SBC200 Dual Charging Station with Power Supply (Quantity: 1 per every 2 transmitters)
    h. Shure UA8 (Provide quantity shown on T-series AV diagrams)
    i. Or Equal

2.36 WIRELESS PRESENTATION RECEIVER

A. Shall meet or exceed the following specifications:

1. Shall have a minimum of one (1) RJ-45 LAN connection.
2. Shall have a minimum of one (1) HDMI output.
3. Shall have a minimum of one (1) USB 2.0 host type A.
4. Shall support resolutions of up to and including 1920x1080 or higher.
5. Shall support Miracast.
6. Provide necessary adapters and accessories as required.
7. Acceptable Manufacturers:

    a. Screenbeam 960
    b. Or Equal

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate incorporation of the Work specified herein with other project work to facilitate a cohesive final product.

B. The installation recommendations contained within ANSI and Telecommunications Distribution Methods Manual are mandatory minimum standards and requirements.

C. Mount equipment and enclosures plumb and level.

D. Permanently installed equipment to be firmly and safely held in place. Design equipment supports to support loads imposed with a safety factor of at least five. Seismic bracing shall be installed on appropriate equipment where local codes require such installation.

E. Verify all locations of equipment in all rooms with Owner’s Representative, Owner, and Consultant.

F. Follow all manufacturer requirements and recommendations for the installation of all AV equipment.

3.2 TESTING

A. Prior to turning on the system, verify all electronic devices are properly grounded and each audio video AC receptacle has the proper hot, neutral, and ground connections.

B. Audio Testing:

1. Verify each amplifier channel is correctly wired by providing a test signal to each channel and verify the correct speakers are operating.
2. Adjust the input and output gain of each device to properly set the system gain.

3. Adjust the output level of each amplifier channel and/or speaker tap settings to achieve 85 dB ± 2 dB in the area covered by the respective speaker zone when the output of the sound reinforcement system is set to 0 dBu.
4. Equalize all loudspeakers to provide an acceptable frequency response based on the specifications of the provided loudspeakers.
5. Verify no hum or buzz is present in the system at all operating levels. If present, propose a resolution and correct the issue at no cost to the Owner.

C. Video Testing:

1. Using a video signal generator, verify performance of all equipment meets manufacturer's specifications.
2. Verify correct operation of all inputs and outputs
3. Flat panel displays shall be set up by the contractor for immediate usage by the Owner once system is commissioned.

3.3 AUDIO VIDEO CONTROL SYSTEM

A. Control system shall be programmed to at a minimum switch between available AV sources, power on/off video displays, raise/lower projection screen, control system volume, and control zone selection of audio where applicable.

B. Contractor to provide a minimum of three iterations of the touchscreen layout and programming for review by the Owner and Consultant. The first phase will involve only the layout and proposed operation. Once reviewed, the Contractor will utilize this information to begin programing the touch panels. The touch panels will be reviewed again after the programming has been implemented in the field. Any changes from this phase shall be incorporated into the work. Final review will occur at the one year walk-through.

C. Control system and room type functionality shall be programmed at a minimum as described below:

1. STUDENT ACTIVITY CENTER

a. Shall include two (2) custom programmed touch panels, one (1) wall mounted in the southeast corner and one (1) wall mounted in the southwest corner, and two (2) custom programmed wireless controllers for system control. At a minimum, control system shall be programmed to switch between available audio sources, source routing, and volume.
b. Confirm all rigging with structural engineer as required.
c. A minimum five (5) foot service loop shall be provided and secured at each loudspeaker location.
d. Contractor shall be required to program and set up system controls within the DSP control processor software.
e. Analog audio shall be routed into or out of the AV/IDF N103d AV equipment rack via XLR, Bluetooth, or 3.5mm connectivity. XLR, 3.5mm, and Bluetooth connections shall terminate to the DSP located in AV/IDF N103d via analog audio cabling. One

microphone input, one line level input, one line level output, one Bluetooth input, and one 3.5mm input shall be installed in the southeast and southwest corners of the student activity center.

f. Contractor shall ensure loudspeaker coverage of 80 dBA at a minimum and no more than 95 dBA at a maximum based on the volume range configured on the touch panel. All areas shall have consistent coverage no greater than ±2 dB.

g. Fiber outlet locations shall be installed on the southeast and southwest corners of the student activity center for future use. The telecommunications contractor shall route and terminate fiber optic cabling as required by the T-series drawings. All video cabling and connectivity to the video scoreboard shall be procured and installed by others.

h. Shall include four (4) wireless microphone channels for voice reinforcement. All wireless microphones shall terminate to the DSP.

i. All audio will be summed, mixed, and processed according to industry standards. Audio from the DSP will feed one zone. Audio will be fed to the power amplifiers over STP cabling via the AV network switch. The loudspeaker configuration shall feed all twenty-two (22) loudspeakers. All loudspeakers shall be wired as shown on the T-series AV diagram allowing for future zoning flexibility.

j. The DSP shall receive an analog audio paging signal from the building paging system. When audio is present, the DSP shall override the program audio to allow the page to be played over the loudspeaker system.

k. Coordinate AV network switch setup requirements with owner. Coordinate all additional AV traffic and protocols on the high school network with the owner prior to programming and commissioning.

2. WRESTLING ROOM

a. Shall include one (1) custom programmed touch panel located in G100 for system control. At a minimum, control system shall be programmed to switch between available audio sources, source routing, and volume.

b. Confirm all rigging with structural engineer as required.

c. A minimum five (5) foot service loop shall be provided and secured at each loudspeaker location.

d. Contractor shall be required to program and set up system controls within the DSP control processor software.

e. Analog audio shall be routed into or out of the G100 AV equipment rack via XLR, Bluetooth, or 3.5mm connectivity. XLR, 3.5mm, and Bluetooth connections shall terminate to the DSP located in G100 via analog audio cabling. One microphone input shall be installed on the southeast and southwest portion of the south wall. One microphone input, one line level input, and one line level output shall be installed in the south center portion of the south wall. One Bluetooth input and one 3.5mm input shall be installed in G100.

f. Contractor shall ensure loudspeaker coverage of 80 dBA at a minimum and no more than 95 dBA at a maximum based on the volume range configured on the touch panel. All areas shall have consistent coverage no greater than ±2 dB.

g. Fiber outlet locations shall be installed on the south wall of the wrestling room south of each wrestling mat. The telecommunications contractor shall route and terminate fiber optic cabling as required by the T-series drawings.
h. Shall include four (4) wireless microphone channels for voice reinforcement. All wireless microphones shall terminate to the DSP.
i. All audio will be summed, mixed, and processed according to industry standards. Audio from the DSP will feed multiple zones. Audio will be fed to the power amplifiers over STP cabling via the AV network switch. Loudspeaker configuration 1 will feed all eighteen (18) loudspeakers. Loudspeaker configuration 2 shall feed four independent zones. Zone 1 shall be configured to feed two loudspeakers over the west wrestling mat and two loudspeakers over the two west upper level bleacher sections. Zone 2 shall be configured to feed two loudspeakers over the center wrestling mat and two loudspeakers over the two center upper level bleacher sections. Zone 3 shall be configured to feed two loudspeakers over the east wrestling mat and two loudspeakers over the two east upper level bleacher sections. Zone 4 shall be configured to feed all six loudspeakers covering the south locker rooms and bathrooms. All loudspeakers shall be wired as shown on the T-series AV diagram.
j. The DSP shall receive an analog audio paging signal from the building paging system. When audio is present, the DSP shall override the program audio to allow the page to be played over the loudspeaker system.
k. Coordinate AV network switch setup requirements with owner. Coordinate all additional AV traffic and protocols on the high school network with the owner prior to programming and commissioning.

3. WEIGHT ROOM

a. Shall include one (1) custom programmed touch panel and one (1) custom programmed wireless controller for system control. At a minimum, control system shall be programmed to switch between available audio sources, source routing, and volume.
b. Confirm all rigging with structural engineer as required.
c. A minimum five (5) foot service loop shall be provided and secured at each loudspeaker location.
d. Contractor shall be required to program and set up system controls within the DSP control processor software.
e. Analog audio shall be routed into or out of the STOR G118a AV equipment rack via XLR, Bluetooth, or 3.5mm connectivity. XLR, 3.5mm, and Bluetooth connections shall terminate to the DSP located in STOR G118a via analog audio cabling. One microphone input, one Bluetooth input, and one 3.5mm input shall be installed in the southeast and southwest corners of the student activity center.
f. Contractor shall ensure loudspeaker coverage of 80 dBA at a minimum and no more than 95 dBA at a maximum based on the volume range configured on the touch panel. All areas shall have consistent coverage no greater than ±2 dB.
g. Shall be programmed to switch between one (1) encoded HDMI input and four (4) wireless presentation receivers.

h. Any of the five (5) video sources shall be capable of routing to any combination of four (4) flat panel displays. Each source and destination shall be selectable at the touch panel or wireless controller according to manufacturer GUI design standards. All video routing will occur over the AV network switch. Coordinate AV network switch setup requirements and all AV traffic and protocols on the high school network with the owner prior to programming and commissioning.
i. Shall include two (2) wireless microphone channels for voice reinforcement. All wireless microphones shall terminate to the DSP.
j. All audio will be summed, mixed, and processed according to industry standards. Audio from the DSP will feed one loudspeaker zone. Audio will feed the power amplifiers over STP cabling via the AV network switch. The loudspeaker configuration shall feed all twelve (12) loudspeakers. All loudspeakers shall be wired as shown on the T-series AV diagram.
k. The DSP shall receive an analog audio paging signal from the building paging system. When audio is present, the DSP shall override the program audio to allow the page to be played over the loudspeaker system.
l. All wireless presentation receivers and flat panel displays shall be connected to the building network.

4. CONFERENCE ROOM G114

a. Shall include one (1) wireless presentation receiver input via a manufacturer approved USB-C to HDMI cable.
b. Shall include one (1) HDMI input.
c. The wireless presentation receiver and the flat panel display shall be connected to the building network

5. ATHLETICS OFFICES G116 & G115

a. Shall include one (1) wireless presentation receiver input via a manufacturer approved USB-C to HDMI cable.
b. The wireless presentation receiver and the flat panel display shall be connected to the building network

3.4 TRAINING

A. After final completion, provide instruction to Owner designated personnel.

B. Provide a minimum of eight (8) hours of training to the Owner. Training session(s) shall cover the following topics at a minimum:

1. System Equipment Connectivity
2. Device Configurations
3. Operation, maintenance, and upgrade procedures.

C. Training to be arranged with Owner personnel. Training schedule shall be coordinated with Owner personnel and their needs.

D. Training to occur in maximum of 2-hour increments per personnel or groups of personnel.

E. Training plan, timeline, and agenda shall be provided to Owner and signed off by Owner and Contractor.

F. Warranty certificate and agreement shall be provided to Owner at initial training session.

G. Provide a digital video copy of the training sessions.

3.5 SYSTEM ACCEPTANCE

A. Contractor shall demonstrate to the Owner and Architect that all systems have been installed per the plans and specifications and that all programming functions, display functions, control functions and all interfaced equipment operate as expected.

B. Contractor shall demonstrate to the Owner and Architect that all the end user staff has a working knowledge of how to operate the installed equipment and that the facilities staff also has a working knowledge of the troubleshooting methods for non-critical service problems.

C. Contractor shall have a Delivery and Acceptance form signed by the Owner representative, agreeing that the installation is complete and its operation is acceptable except as noted on the Delivery and Acceptance form. This will also serve as the start of the warranty period.

D. Contractor shall work with the General Contractor to complete all punch lists and work required to allow the General Contractor to close out the project in a timely manner. This will include but not limited to any work that would impact any final inspection for turnover of the building.

END OF SECTION 27 41 16

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PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section includes the minimum requirements for the installation, configuration, and training of the audio-visual components as depicted on the Drawings and required by these specifications.

B. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether or not specified or shown on the drawings.

C. This section includes minimum requirements for the following:

1. BRUSHED GROMMET
2. CLASSROOM MODULE
3. HIGH SECURITY INTERCOM STATION
4. PAGING AMPLIFIER TYPE 1
5. PAGING AMPLIFIER TYPE 2
6. ONE WAY PAGING SPEAKER
7. ONE WAY PAGING HORN
8. ZONE PAGE MODULE

D. Related Sections include the following:

1. Division 26 – Electrical
2. 27 05 00 – Common Work Results for Communications
3. 27 05 28 – Pathways for Communications Systems
4. 27 15 13 – Communications Copper Horizontal Cabling
5. 27 15 00.23 – Audio-Video Communications Horizontal Cabling

1.2 QUALITY ASSURANCE

A. The following industry Standards are the basis for the audio-visual system described herein. The list is incorporated by this reference to them.

1. ANSI - American National Safety Institute
2. ASTM - American Society of Testing and Materials
3. EIA - Electronics Industries Association
4. FCC - Federal Communications Commission
5. NEMA - National Electrical Manufacturer’s Association
6. OSHA - Occupational Safety and Health Administration
7. NEC - National Electric Code.
8. NFPA - National Fire Protection Association, NFPA-70
9. IEEE - Institute of Electrical and Electronics Engineers.
10. ISO - International Standards Organization.

11. UL - Underwriters Laboratories
12. BICSI Telecommunications Distribution Methods Manual (TDMM)
13. Americans with Disabilities Act (ADA)
14. Davis and Davis, Sound System Engineering (2nd Edition), Howard W. Sams, 1987
15. Giddings, Audio System Design and Installation (ASDI), Howard W. Sams, 1990
16. Infocomm International Installation Handbook.

B. All cable 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 Architect and Owners Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "Or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

C. Materials and work specified herein shall comply with the requirements of the local Authority Having Jurisdiction. Refer to Section 270500 for all applicable standards and codes.

D. Contractor should have the following qualifications:

1. Experienced in the installation of systems similar in complexity and scale to those included within the scope of work. If requested, the Contractor shall provide the names, locations, and points of contact for at least three installations of the type and complexity specified herein.
2. Within the last two (2) years, installed an audio-visual system with similar equipment and functionality.
3. Have at least one (1) person on staff with CTS-I certification.

1.3 SUBMITTALS

A. As part of this specification section, Contractor shall be responsible for providing the following submittals.
   1. Manufacturer Product Data
   2. Pre-Installation Shop Drawings
   3. As-Built Drawings
   4. Configuration files and Source Code

B. Manufacturer Product Data - The Contractor shall provide manufacturers' catalog sheets, specifications, and installation instructions for all products to be installed within the scope of work. This is to verify that the submitted components comply with the Contract Documents. Submittals shall be formatted as follows.

   1. Submit only products that appear in this section or that are required for a complete installation relating to the products in this section. Submission of products from multiple sections will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.
   2. Each product intended to be used shall be included one time only. Do not submit similar products multiple times.
   3. Submittal shall include an index with page(s) listed in order of specification within corresponding section, with subsection number and generic name correlated to product submitted. Sheet index and/or product data sheets organized alphabetically, randomly or in any

manner which does not match the specification order will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.

4. Following index sheet, include Manufacturer specification sheet stapled in order of properly organized index.
   a. Where multiple products exist on a single sheet, Contractor shall clearly indicate, whether with highlight, arrow, PDF stamp, etc. the product intending to be used.
   b. Failure to indicate specific product to be used will be cause for marking submittal Revise and Resubmit.

C. Pre-Installation Shop Drawings – Prior to the start of field work the Contractor shall provide pre-installation shop drawings noting the intended installation means and methods for this scope of work. This is to ensure the Contractor understands the scope of work and to provide the field installation teams with all information necessary for successful implementation.

1. Drawings shall be created using modeling software, such as Autodesk AutoCAD. In addition, they shall be exported in PDF format for review by the designer and Owner.
2. Drawings shall contain floor plans, RCPs (if applicable), section views, and details illustrating equipment location, including but not limited equipment racks, IR amplifiers, projection screens, connection panels, flat panel displays, and loudspeakers. Drawings shall be at no less than 1/8"=1'-0" scale.
3. Detailed wiring diagrams showing the interconnection between equipment devices. This shall include cable labeling, cable types, connector types and termination details, wiring color codes, and equipment manufacturer and models. Note cabling provided by Others. Diagrams included as part of Construction Documents are included to convey design intent and are not acceptable for use in Pre-Installation Shop Drawings and will be cause for rejection.
4. Dimensioned plate and panel details that are custom for the project. Details shall include dimensioned locations of components, component type, engraving information, bill of materials, and plate finish and color. If custom part numbers are generated by a manufacturer, they shall be included on the plate details.
5. Rack elevations showing equipment layout within racks with dimensions. The Contractor shall allocate space in the rack for all equipment that will ultimately be installed within, including any and all Owner Furnished equipment.
6. Wiring schedule showing the source and destination of wiring and indicating whether the wire is in conduit or cable tray.

D. As-Built Drawings - The Contractor shall provide Final documentation noting the actual installed conditions for this scope of work. This is to provide the Owner with accurate historical data of the project for future reference. As-Built Drawings shall be submitted during project close-out for inclusion in the O&M manual. Submittals shall be formatted as follows.

1. Submit one (1) PDF set of redlined Contractor generated As-Built Drawings. The Owner reserves the right to request an electronic copy of the shop drawings in both Autodesk CAD (.DWG) format and PDF format.
2. As-Built Drawings that utilize the Contract Documents as a base, shall be inclusive of all Published Addendums, ASIs, Accepted PCOs, PRs, SIs, etc. Changes made via RFI or Field Directive that were not published changes to the Contract Drawings shall be noted as such on the As-Builts with the noted RFI or FD #.
3. All text notes included on As-Builts shall be easily legible on PDF. Handwritten notes that are not legible shall be replaced with PDF text.
4. Include equipment manufacturer/model as installed in the field.

5. Include revised functional diagrams based on those submitted and approved during the Pre-Installation Shop Drawing submittal

D. Configuration Files and Source Code – The Contractor shall provide the final equipment configuration files and Source Code installed on the project. These files shall be submitted concurrently with As-Built Drawings.
   1. Include configuration files for all equipment, including but not limited to, digital signal processors, video switchers, control processors, amplifiers, etc. Owner notes that any changes made during the warranty period not completed by the Contractor will void the system warranty.
   2. Include any passwords that may have been created that are required to access equipment. Owner notes that any changes made during the warranty period not completed by the Contractor will void the system warranty.
   3. Contractor is not required to provide manufacturer software used for configuration.
   4. Include any control processor source code in its uncompiled format. Owner notes that any changes made during the warranty period not completed by the Contractor will void the system warranty.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Equipment and components shall arrive onsite properly protected and undamaged with containers, packaging and labels intact.

B. Store, handle and protect materials and equipment in accordance with Manufacturer's recommendations.

C. Store materials and equipment in dry, environmentally controlled space. Do not install equipment and materials until spaces are enclosed, watertight, and dry. Protect equipment from dust and other airborne materials.

D. Provide additional protection during handling as necessary to prevent breaking scraping, marring, or otherwise damaging products or surrounding areas.

E. Protect all equipment and components that are to be installed within this project from theft, vandalism, and exposure to rain, freezing temperatures and direct sunlight.

F. Protect installed equipment and components from damage and prevent use by unauthorized persons.

1.5 WARRANTY

A. The Contractor shall warrantee the completed work for a period of one (1) year, from the date of acceptance of the work, to be free of defect in design, workmanship, or material.

B. Contractor shall repair, adjust, and/or replace, whichever the District determines to be in its best interests, any defective equipment, materials, or workmanship, as well as such parts of the work damaged or destroyed by such defect, during the warranty period, at the Contractor’s sole cost and expense. If parts or components need to be repaired, then a loaner will be supplied and installed until the part or component can be repaired and reinstalled.

C. All service work shall be performed by manufacturer certified technicians.

D. Contractor to provide District a phone number for technical support. All support calls shall be answered within twenty-four (24) hours. All repairs shall be underway within forty-eight (48) hours and completed (or loaner supplied) within seven (7) days.

E. In the event that the Contractor does not affect repair within forty-eight (48) hours from the date of notification of such defect, the District may secure repair services from other sources and charge the Contractor for such costs without voiding the warranty.

F. At the end of the warranty period, the Contractor shall complete one (1) site visit to evaluate the status of the paging system. All equipment within this scope of work found to be defective shall be replaced at no cost to the District.

G. Guarantees of material, equipment, and workmanship running in favor of the Contractor shall be transferred and assigned to the District on completion of the work and acceptance of said work by the District.

PART 2 - PRODUCTS

2.1 GENERAL

A. All products to be new and shipped in accordance with manufacturer recommendations.

B. Replace, without costs to the Owner, any products damaged during shipping or installation.

C. All products shall be capable of full integration within the existing Bogen Nyquist system.

2.2 BRUSHED GROMMET

A. Shall meet or exceed the following specifications:
   1. Shall be 1 RU.
   2. Shall allow for cables to be safely and cleanly passed from the front of the rack to the interior of the rack.
   3. Acceptable Manufacturers:

      a. Middle Atlantic BR-1

2.3 CLASSROOM MODULE

A. Shall meet or exceed the following specifications:
   1. Shall have an RJ45 port for connection to network.
   2. Shall support up to 24 classroom speaker circuits.
   3. Shall support 25 volt speakers.
   4. Shall provide a total of 25 Watts power (5 Watts max. per port).
   5. Shall be compatible with existing Telecenter TCC2000 Controller
   6. Contractor to provide compatible 66 block and mounting.

   7. Acceptable Manufacturers:

a. Rauland Telecenter TCC2024 Twenty-Four Port Gateway

2.4 HIGH SECURITY INTERCOM STATION

A. Shall meet or exceed the following specifications:
1. Shall have an RJ45 port for connection to network.
2. Shall support up to 24 classroom speaker circuits.
3. Shall support 25 volt speakers.
4. Shall provide a total of 25 Watts power (5 Watts max. per port).
5. Shall be compatible with existing Telecenter TCC2000 Controller
6. Contractor to provide compatible 66 block and mounting.

7. Acceptable Manufacturers:

a. Rauland Telecenter TCC2024 Twenty-Four Port Gateway

2.5 PAGING AMPLIFIER TYPE 1

A. Shall meet or exceed the following specifications:

1. Shall have an RJ45 port for connectivity to the building network.
2. Shall have one (1) channel of power amplification capable of a minimum of 25W into a 25V load.
3. Shall have a frequency response of 50Hz – 20kHz.
4. Shall have a THD+N of less than 0.5% at 1kHz.
5. Shall be 1RU rack mountable.
6. Acceptable Manufacturers:

a. Stewart Audio CVA25-1 25V
b. Or Equal

2.6 PAGING AMPLIFIER TYPE 2

A. Shall meet or exceed the following specifications:

1. Shall have an RJ45 port for connectivity to the building network.
2. Shall have one (1) channel of power amplification capable of a minimum of 50W into a 70V load.
3. Shall have a frequency response of 50Hz – 20kHz.
4. Shall have a THD+N of less than 0.5% at 1kHz.
5. Shall be 1RU rack mountable.
6. Acceptable Manufacturers:

a. Stewart Audio CVA50-1
b. Or Equal

2.7 ONE-WAY PAGING SPEAKERS

A. Contractor shall provide and install one-way paging speakers as shown on the T-series drawings.

B. Shall meet or exceed the following specifications:

1. Shall have an 8” driver.
2. Shall have a minimum frequency response of 95Hz to 15kHz.
3. Shall have a minimum sensitivity of 92dB at 1m with 1 watt of input.
4. Shall have a 25V internal transformer with taps at a minimum of 0.35, 0.5, 1, 2, and 4W.
5. Shall have a 2x2 ceiling grid form factor unless installed within a gypsum board or open ceilings. If speaker shall be installed in inaccessible or open ceilings, contractor shall provide the necessary mounting back cans, enclosures, and hardware to install the speaker within the required ceiling space.
6. Speakers shall be tapped at a minimum of 0.5W.
7. One way paging speakers shall be ceiling mounted. Contractor to provide all necessary accessories to support speakers.
8. Confirm color and finish with architect.
9. Acceptable Manufacturers:

    a. Rauland
    b. Or equal

2.8 ONE-WAY PAGING HORN

A. Contractor shall provide and install one-way paging speakers as shown on the T-series drawings.

B. Shall meet or exceed the following specifications:

1. Shall have an 8” driver.
2. Shall have a minimum frequency response of 375Hz to 14kHz.
3. Shall have a minimum sensitivity of 110dB at 1m with 1 watt of input.
4. Shall have a 70V selectable transformer with taps at a minimum of 1.8, 3.7, 7.5, 15 and 30W.
5. Shall have a 25V selectable transformer with taps at a minimum of 1.8, 3.7, 7.5 and 15W.
6. Speakers shall be tapped at a minimum of 15W.
7. One way paging horns shall be wall mounted. Contractor to provide all necessary accessories to support speakers.
8. Confirm color and finish with architect.
9. Acceptable Manufacturers:

    a. Rauland
    b. Or equal

2.9 ZONE PAGE MODULE

A. Shall meet or exceed the following specifications:
1. Shall have an RJ45 port for connection to network.
2. Shall be PoE powered.
3. Shall have 1.0 VRMS audio output.
4. Shall provide DPDT relay output.
5. Shall be compatible with existing Telecenter TCC2000 Controller
6. Contractor to provide rack mounting shelf.

7. Acceptable Manufacturers:

    a. Rauland Telecenter TCC2024 Twenty-Four Port Gateway
    b. Or Equal

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate incorporation of the Work specified herein with other project work so as to facilitate a cohesive final product.

B. The installation recommendations contained within ASDI and Telecommunications Distribution Methods Manual are mandatory minimum standards and requirements.

C. Mount equipment and enclosures plumb and level.

D. Permanently installed equipment to be firmly and safely held in place. Design equipment supports to support loads imposed with a safety factor of at least five. Seismic bracing shall be installed on appropriate equipment where local codes require such installation.

E. Verify all locations of equipment in all rooms with Owner's Representative, Owner, and Consultant.

3.2 TESTING

A. Prior to turning on the system, verify all electronic devices are properly grounded and each audio video AC receptacle has the proper hot, neutral, and ground connections.

B. Audio Testing:

1. Verify each amplifier channel is correctly wired by providing a test signal to each channel and verify the correct speakers are operating.
2. Adjust the input and output gain of each device to properly set the system gain.
3. Adjust the output level of each amplifier channel and/or speaker tap settings to achieve 85 dB ± 2 dB in the area covered by the respective speaker zone when the output of gateway is set to 0 dBu.
4. Equalize all loudspeakers to provide an acceptable frequency response based on the specifications of the provided loudspeakers.
5. Verify no hum or buzz is present in the system at all operating levels. If present, propose a resolution and correct the issue at no cost to the Owner.
6. Verify VoIP system is properly configured and integrated with paging system by testing various extensions for individual paging zones.

3.3 TRAINING

A. Provide a minimum of four (4) hours of training to the Owner's personnel. Plan for multiple training trips to the site. Training session(s) shall cover the following topics at a minimum:

1. System Equipment Connectivity
2. Device Configurations
3. Operation, maintenance, and upgrade procedures.

B. Training may occur in maximum of 2 hour increments per personnel or groups of personnel.

C. Contractor may provide manufacturer training vouchers for a portion of the training, which are valid during the warranty period.

D. Training shall be by certified manufacturer instructor.

E. Training schedule shall be coordinated with Owner personnel and their needs.

F. Training plan, timeline, and agenda shall be provided to Owner IT personnel and signed off by the Owner and Contractor.

G. Warranty certificate and agreement shall be provided to the Owner and IT personnel at initial training session.

H. Provide a digital video copy of the training sessions if applicable.

3.4 SYSTEM ACCEPTANCE

A. Contractor shall demonstrate to the Owner that all systems have been installed per the plans and specifications and that all programming functions, display functions, control functions and all interfaced equipment operate as expected.

B. Contractor shall demonstrate to the Owner that all the end user staff has a working knowledge of how to operate the installed equipment and that the facilities staff also has a working knowledge of the troubleshooting methods for non-critical service problems.

C. Contractor shall have a Delivery and Acceptance form signed by the Owner representative, agreeing that the installation is complete and its operation is acceptable except as noted on the Delivery and Acceptance form. This will also serve as the start of the warranty period.

D. Contractor shall work with the General Contractor to complete all punch lists and work required to allow the General Contractor to close out his project in a timely manner. This will include but not limited to any work that would impact any final inspection for turnover of the building.

END OF SECTION 27 51 23

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PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The scope of the project consists of expanding the existing CDVI Atrium electronic access control system (EACS). The work required under this section consists of providing labor, equipment, programming, licenses, materials, and testing unless otherwise specified, and to perform the operations recognized as necessary for the installation, termination, and labeling of conduits, boxes, raceways, etc., and the wiring of the access control system. Access control wiring includes cables for card readers, electrified door hardware, and ADA operator integration.

1.2 RELATED SECTIONS

A. Related sections include the following:

1. 08 70 00 - Door Hardware
2. 26 00 00 - Electrical
3. 27 00 00 - Communications

1.3 INTENT OF DRAWINGS AND SPECIFICATIONS

A. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether or not specified or shown on the Drawings.

1.4 DEFINITIONS

A. Card Reader Door- Any door consisting of at least (1) card reader and that is monitored with the access control system for open/closed status.

B. Power Transfer – Device connected to the door, on hinged side, and to the door frame for the purpose of transferring wires from the door frame to the door for monitoring and controlling the latches.

C. Secure side – The secure side of a card reader door is the side which cannot be accessed unless a valid credential is presented.

D. Unsecure side – The unsecure side of a card reader door is the side which can be approached regardless of credential status. The card reader is installed on the unsecure side of an opening.

1.5 SUBMITTALS

A. As part of this specification section, Contractor shall be responsible for providing the following submittals.

1. Manufacturer Product Data
2. Pre-Installation Shop Drawings
3. As-Built Drawings

B. Manufacturer Product Data - The Contractor shall provide manufacturers' catalog sheets, specifications, and installation instructions for all products to be installed within the scope of work. This is to verify that the submitted components comply with the Contract Documents. Submittals shall be formatted as follows.

1. Submit only products that appear in this section or that are required for a complete installation relating to the products in this section. Submission of products from multiple sections will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.
2. Product data for each product intended for installation shall be included once per submittal only. Duplicate copies of product data are not permitted.
3. Submittal shall include an overall index with page(s) listed in order of specification within corresponding section, with subsection number and generic name correlated to product submitted. Sheet index and/or product data sheets organized alphabetically, randomly or in any manner which does not match the specification order will be cause for rejection of submittal without review and subject to reformatting and resubmittal by Contractor.
4. Following index pages, include Manufacturer specification sheet stapled in order of properly organized index.

    a. Where multiple products exist on a single sheet, Contractor shall clearly indicate, whether with highlight, arrow, PDF stamp, etc. the product intending to be used.
    b. Failure to indicate specific product to be used will be cause for marking submittal Revise and Resubmit.

C. Pre-Installation Shop Drawings – Prior to the start of field work the Contractor shall provide pre-installation shop drawings noting the intended installation means and methods for this scope of work. This is to ensure the Contractor understands the scope of work and to provide the field installation teams with all information necessary for successful implementation.

1. Drawings shall be created using modeling software, such as Autodesk AutoCAD. In addition, drawings shall be exported in PDF format for review and approval by the designer and Owner.
2. Where multiple scopes of work are included on one Shop Drawing Submittal (ex. video security, intrusion detection, access control), submittal will be approved or rejected as a whole.
3. Drawings shall contain floor plans, RCPs, section views, and details illustrating equipment location, including but not limited to card readers, REXs, door position

sensors, and head end equipment. Drawings shall be at no less than 1/8"=1'-0" scale.

4. Detailed wiring diagrams showing the interconnection between equipment devices. This shall include cable labeling, cable types, connector types and termination details, wiring color codes, and equipment manufacturer and models. Note cabling provided by Others. Diagrams included as part of Construction Documents are included to convey design intent and are not acceptable for use in Pre-Installation Shop Drawings and will be cause for rejection.
5. Door details including hardware type, manufacturer, and model numbers. The details included in the Construction Documents are included to convey design intent and are not acceptable for use in Pre-Installation Shop Drawings and will be cause for rejection.

D. As-Built Drawings - The Contractor shall provide Final documentation noting the actual installed conditions for this scope of work. This is to provide the Owner with accurate historical data of the project for future reference. As-Built Drawings shall be submitted during project close-out for inclusion in the O&M manual. Submittals shall be formatted as follows.

1. Submit one (1) PDF set of redlined Contractor generated As-Built Drawings. The Owner reserves the right to request an electronic copy of the as-built drawings in both Autodesk CAD (.DWG) format and PDF format.
2. As-Built Drawings that utilize the Contract Documents as a base, shall be inclusive of all Published Addendums, ASIs, Accepted PCOs, PRs, SIs, etc. Changes made via RFI or Field Directive that were not published changes to the Contract Drawings shall be noted as such on the As-Builts with the noted RFI or FD #.
3. All text notes included on As-Builts shall be easily legible on PDF. Handwritten notes that are not legible shall be replaced with PDF text.
4. Include equipment manufacturer/model as installed in the field. Include door/monitoring point names as configured in software to allow Owner easy reference for future.
5. Include any deviations from published schedules.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the product manufacturer for both installation and maintenance of units required for this Project. The installer shall have a minimum of three (3) years documented experience installing and servicing access control systems.

B. Manufacturer Qualifications: A firm experienced in manufacturing equipment similar to that indicated for this Project and that maintains technical support services capable of providing user with training, parts, and emergency maintenance and repair with a 24-hour maximum response time. The manufacturer of the product specified in this section shall have a minimum of five (5) years of documented experience in the manufacture and design of access control systems.

C. Source Limitations: Obtain security equipment components through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. The access control system shall conform to all local and state jurisdiction requirements.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Card Readers: Furnish quantity equal to ten (10) percent of quantity installed, but not fewer than one (1).

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

A. All new components installed as part of this project shall be fully compatible with the existing CDVI Atrium EACS.

B. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.

C. Equipment: Solid state, modular.

D. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.

2.2 SYSTEM CONTROL MODULES

A. Contractor shall provide and install new system control modules as required within telecom rooms and meeting the following minimum requirements:

1. Shall include lockable, wall-mountable enclosure(s) with tamper switch.
2. Shall feature removable backplate with hole patterns specific to required control boards.
3. Shall include power supply and control boards as noted below.
4. Acceptable manufacturer and models:

a. CDVI A22K System Control Module (No exceptions)

B. Contractor shall provide and install 12 VDC 7 Ah battery back-up within each enclosure.
C. Submit enclosure cut sheets as required in the submittal section of this specification.

D. In each telecom room to which card reader doors will be cabled, contractor shall provide one (1) A22K control module connected to building LAN via ethernet and configured as a Sub-Controller, with additional A22K modules connected via RS485 bus and configured as Expanders as required for quantity of card reader doors being served from the room.

2.3 ACCESS CONTROL CARD READERS

A. Contractor shall provide and install card readers at locations shown on the drawings.

B. Card readers shall meet the following minimum requirements:

1. Shall be fully compatible with the CDVI Atrium access control system and credentials.
2. Shall include integrated keypad.

C. Acceptable Manufacturer and model:

1. CDVI SOLARKPB (No exceptions)
2. Submit card reader cut sheets as required in the submittal section of this technical specification.

2.4 POWER FOR ELECTRONIC LOCKING HARDWARE

A. All electrified hardware at card reader doors shall be powered via the associated A22K control module power supply. Coordinate with Division 08 contractor for power and connectivity requirements for integration of electrified hardware.

2.5 VIDEO INTERCOM DOOR STATIONS

A. Contractor shall provide and install a new video intercom door station at the locations shown on the T-Series Drawings. Video intercom door stations shall meet the following specifications:

1. Vandal and weather resistant unit rated for indoor or outdoor use.
2. Shall communicate via the building local area network.
3. 802.3af PoE compliant.
4. Capable of SIP communication with building VoIP system.
5. Capable of up to 1080p resolution.
6. Acceptable Manufacturer & model:

a. Aiphone IX Series
b. Or approved equal

2.6 VIDEO INTERCOM ANSWERING STATION

A. Contractor shall provide and install a new video intercom answering station in the existing school reception area meeting the following specifications:

1. Shall capacitive multi-point touchscreen.
2. Shall include physical handset.
3. Shall communicate via the building local area network.
4. 802.3af PoE compliant.
5. Capable of SIP communication with building VoIP system.
6. Capable of integration with Access Control System to allow release of electronic door locks.
7. Acceptable Manufacturers

a. Aiphone IX Series
b. Or approved equal.

2.7 CABLES

A. Contractor shall provide, install and terminate all required cables to complete the scope of the Access Control System installation.

B. Access Control Cabling from access control modules to components at access-controlled openings shall be composite, multi-conductor cabling designed specifically for access control system wiring.

1. Acceptable manufacturers:

a. Belden
b. Windy City Wire
c. West Penn Wire
d. Or approved equal

C. RS-485 cabling, if required, shall meet the following minimum requirements:

1. Shall be low capacitance shielded cable with two (2) twisted pairs
2. Individual conductors shall be minimum 24 AWG stranded tinned copper
3. Minimum 24 AWG tinned copper drain wire
4. Nominal Impedance 120 Ohm
5. Shall be plenum rated as required
6. Acceptable products

a. Belden 82842
b. Windy City Wire 042003
c. Or approved equivalent

2.8 VIDEO INTERCOM CABLING

A. New video intercom devices installed in the new addition shall utilize UTP ethernet cabling. Refer to Division 27 specifications for full requirements.

B. New video intercom devices installed as replacements for existing devices shall utilize existing 2-conductor wire with analog to IP converters as defined above. Patch cables shall be provided as required and as defined in the Division 27 specifications. Data connectivity for these devices shall be provided under division 27 scope.

2.9 ELECTRONIC LOCKING TECHNOLOGY – PROVIDED BY DIVISION 8

A. The security Contractor shall coordinate with the door hardware Contractor on the placement of required electronic locking hardware. The door Contractor will provide and install all electronic locking hardware, and local power supplies where applicable. The security Contractor shall

interface electronic locking hardware equipment with the access control system and power supplies.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring Method: Install wiring in raceway except within consoles, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

B. Wiring Method: All wiring is to be installed in conduit except as mentioned in part 3.1A above.

C. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150mm) from cabinets, boxes, or fittings.

D. Wiring within Enclosures: Provide adequate length of conductors. Bundle, lace, and train conductors to terminal points with no excess. Provide and use lacing bars in cabinets.

E. Separation of Wires: Run in separate raceways or, if exposed or in same enclosure, provide 12-inch (300 mm) minimum separation between conductors adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.

F. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets, and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.

G. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.

H. Identification of Conductors and Cables: Retain color-coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams. Label stations, controls, and indications using approved consistent nomenclature.

3.2 PROGRAMMING

A. Contractor shall provide programming and configuration of the system as required by the owner, including but not limited to integrating new doors into existing user database, user groups and access levels, implementing active/inactive hours for card reader operation, scheduled locking/unlocking, and lockdown initiation (if utilized by the school).

B. Card reader keypads are utilized by EMS responders for emergency access to the facility. Programming shall include integration of keypad and associated access codes for EMS access at all card reader doors.

1. Contractor shall schedule a minimum of two (2) meetings with the owner to discuss and coordinate full programming requirements. Meetings shall be planned as follows:
    a. Initial meeting to discuss current system configuration, available configuration options, and detailed programming requirements including scheduling requirements per door.
    b. A second meeting shall be held once initial programming is complete to demonstrate configuration and review for any potential adjustments.

3.3 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.

C. Grounding Provisions: Comply with requirements in Division 26 Section "Grounding".

3.4 CARD READER DOORS

A. A card reader door consists of a 6" square by 4" deep box mounted above ceiling on the secure side of the opening with one (1) 1" EMT continuous conduit from the box to within 18" to 24" of the hallway distribution system.

B. If door is equipped with ADA Auto Door Opener install ¾" EMT to control for interface.

C. Refer to EAC door type details within T-series drawings for specific box and conduit requirements for different openings.

3.5 CABLE HANGERS

A. J-hooks shall be installed per ANSI/EIA/TIA 569 Commercial Building Standards for Telecommunications Pathways and Spaces.

B. Provide cable hangers a maximum of 5’ on center wherever cable tray or conduit is not present.

C. Load hangers as recommended by the manufacturer. Provide hangers side by side on a common bracket where cable quantities require.

D. Do not install cables loose above lock-in type, drywall or plaster ceilings.

E. Cables shall be installed at least six (6) inches above the ceiling tiles and shall not touch the ceiling.

F. Do not support cable from ceiling system tie wires or grid in fire rated systems.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field assembled components and testing and adjusting of system.

B. Test Procedure: Comply with the following:

1. Schedule tests a minimum of seven days in advance of performance of tests.
2. Report: Submit a written record of test results.
3. Operational Test: Perform an operational system test to verify compliance of system with these Specifications.

C. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets these Specifications and complies with applicable standards. Report results in writing.

D. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

E. System Testing:

1. All Card Reader doors shall be tested for proper operation as required. Any operational failures discovered during testing shall be remedied and re-tested until proper operation is confirmed.

END OF SECTION 28 13 00

SECTION 28 23 00 – VIDEO SECURITY 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 SUMMARY

A. Provide all work as detailed in the Contract Drawings as a turn-key expansion of the existing video security system, including all material, licenses, labor, programming, as-built documentation, warranties, taxes, freight and permits. Only items and requirements specifically stated to be provided under another section shall not be a requirement for this section of the work.

B. The end product which the contractor is to produce shall be fully operational and functional video security cameras integrated into the existing district Exacqvision video security system.

C. Provide the following Systems and Equipment:

1. Security Cameras, housings and mounts
2. Power supplies (if needed)
3. Long Range PoE Extenders (if needed)

D. Coordinate all installation and integration of the security system with the following related systems:

1. Division 27 - Communications

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the Contract Documents.

1.4 QUALITY ASSURANCE

A. Contractor Qualifications:

1. All work specified herein shall be the responsibility of the Contractor. Contractors shall document a minimum of five years' experience in the fabrication, assembly and installation of system of similar complexity as specified herein. The documentation shall include the names, locations and points of contact for at least three installations of the type and complexity specified herein. The contractors shall provide a brief overview of each system detailing what video system was used; the amount of equipment installed; and certify that the system has been in operation for a minimum of 24 months.
2. The Contractor shall have a service facility and organization with staffing capable of

providing comprehensive maintenance and service to the specified systems within 4 hours after being called, 24 hours per day and 7 days per week for the duration of any warranty or service contract.

3. The Contractor shall provide in-house engineering and project management capabilities consistent with the requirements of the work. The Contractor shall have a project manager and field supervisor in place which oversees the entire project till completion of the project. The assigned project manager will be responsible for coordination, scheduling, manpower, commissioning etc. of the project. The Contractor's field supervisor shall be present during the full duration of the project to oversee field installations and to coordinate with other trades to ensure progress on the project.
4. The Contractor must be familiar with local codes and contract conditions pertaining to this project.

B. Product Standards:

1. All materials installed on this or any other project must be new and the latest specification and version from the manufacturer.
2. All products installed shall be what is depicted in these specifications with no exceptions.

1.5 SUBMITTALS

A. General:

1. All submitted data shall be specific to this project and identified as such. Generic submittal data will not be accepted.
2. Product submittals shall include detailed specification data for all installed devices, equipment and accessories.
3. Shop drawing submittals shall consist of scaled floor plans and shall, at a minimum, identify all camera locations, view directions, specific camera model information per location, any accessories planned (such as PoE Injector, external heater, etc.) at each location, and cabling termination locations.

B. Product Data:

1. Manufacturers' descriptive literature, illustrations and installation instructions for all components included within this project indicating compliance with applicable referenced standards, size, dimensions, model number, electrical characteristics, support requirements, connection requirements and all applicable information verifying that submitted components comply with Contract Documents.

C. Record Documents:

1. Identify component locations on the record drawings.
2. Contractor shall provide as part of the record documents a spreadsheet which corresponds with the camera locations shown on the record drawings and lists identifiable camera details such as MAC Address and Make/Model per location. Coordinate with the owner to confirm specific information to be listed.
3. Manufacturer's warranty form in which manufacturer agrees to repair or replace components that fail, in materials or workmanship, within specified warranty period.

D. Operation and Maintenance Data:

1. Operation Data:

   a. Include manufacturer's installation and operating instructions.

2. Maintenance Data:

   a. Servicing requirements, inspection data, preventative maintenance schedule,

exploded assembly views, replacement part numbers and availability, location and contact numbers of service depot.

1.6 DELIVERY, STORAGE and HANDLING

A. Equipment and components shall arrive onsite properly protected and undamaged with containers, packaging and labels intact.

B. Store, handle and protect materials and equipment in accordance with Manufacturer's recommendations.

C. Provide additional protection during handling as necessary to prevent breaking scraping, marring, or otherwise damaging products or surrounding areas.

D. Protect all equipment and components that are to be installed within this project from theft, vandalism, and exposure to rain, freezing temperatures and direct sunlight.

E. Protect installed equipment and components from damage and prevent use by unauthorized persons.

1.7 EXTRA MATERIALS

A. Spare Parts:

1. The Contractor will maintain a spare parts inventory to resolve any critical component failure the day of the incident. Critical components shall be:

a. Security Cameras
b. Power Distribution Unit Components (any and all components)

1.8 WARRANTY AND SERVICE

A. Warranty:

1. The Contractor shall warrantee the completed work for a period of one year, from the date of commissioning, to be free of defect in design, workmanship or material.

B. Warranty Service:

1. In the event that defects in the materials and/or workmanship are identified during the warranty period, the contractor shall provide all labor and materials to correct the deficiency.
2. All service work shall be performed by manufacturer-certified technicians.
3. All warranty service shall include the replacement of all parts and or components as required to restore normal system operation. If parts or components need to be repaired, then a loaner will be supplied and installed until the part or component can be repaired and reinstalled.
4. Immediately following a warranty service request, the Contractor shall provide written documentation to the owner which details the service work completed, cause of trouble and any outstanding work required to restore a complete and normal system.

C. Repair or Replacement Service:

1. Service shall be completed within 48 hours from site arrival. If the failure exceeds 48 hours, the Owner reserves the right to require the Contractor to provide onsite manufacturer support at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of Authorities Having Jurisdiction.

B. The contractor shall provide new IP video security cameras and associated licenses, mounting hardware and accessories, back boxes and cable pathways, cabling, camera set-up and system programming.

C. Each new video security camera location shall require ceiling, wall, or exterior corner mounting. Contractor shall include all mounting hardware and accessories as needed for a complete and functional camera location. Where camera locations would result in cabling distances exceeding the maximum allowable distance for ethernet connectivity, contractor shall provide PoE extender systems as needed to ensure full functionality of each camera.

D. Video from each camera shall be transmitted on the building local area network. Power for cameras shall be provided by the owner's PoE network switches. Contractor shall calculate PoE requirements for actual camera models provided and coordinate with the owner to determine PoE budgets of owner furnished switches. Where camera power requirements exceed the PoE budget of the owner's switches the contractor shall provide PoE injectors as required to supply sufficient power.

2.2 NETWORK VIDEO RECORDING SERVER

A. The Contractor shall provide and install a minimum of one (1) new NVR server. NVR server(s) shall not exceed 80% of the Manufacturer's stated maximum capacity for camera inputs. Additional NVR servers shall be provided as required to accommodate the total quantity of camera sensors within each building. Contractor shall coordinate with the owner to confirm NVR location, LAN network addressing schemes and programming requirements. All new NVR servers shall meet the following minimum requirements:

1. Shall be rack-mountable. Contractor shall coordinate with the telecom contractor for location of the server within the telecom equipment rack.
2. Storage capacity of all NVRs provided as part of this project shall be calculated by the contractor based on the following requirements:
    a. Recording shall be motion based plus continuous low-resolution recording where available.
    b. Recorded video retention period shall be no fewer than thirty (30) days.
    c. Frame rate for primary stream recorded footage shall be no lower than 15 frames per second.
    d. Primary stream shall utilize H.264 compression.
    e. Primary stream shall be recorded at highest available quality.
    f. Storage shall be calculated per NVR based on actual new camera models and sensor quantities and existing camera sensor quantities and resolutions to be recorded to each NVR.
3. Initial storage capacity shall be no less than 25% above the minimum capacity calculated according to the above requirements.
4. All NVRs shall include integrated RAID capability.
5. Maximum camera stream capacity shall be 150 or greater.
6. Minimum 16GB RAM.
7. Minimum two (2) 1Gbps LAN ports.
8. Redundant power supplies.

B. Contractor shall provide adequate licenses for all new and existing camera locations to ensure they are recorded on the new NVR.

C. All NVRs shall run on Windows based operating systems. Video Management Software (VMS) must be factory installed on the recorder.

D. Shall be rack mounted. Coordinate with the Owner for final installation location.
E. Warranty shall be a minimum of three (3) years.
F. Acceptable Manufacturer and model:

1. Exacq Technologies A-Series FAR
2. Exacq Technologies X-Series 2U
3. Or approved equal

G. Contractor shall provide adequate licenses for all new camera locations to ensure they are recorded on the existing NVR.

2.3 VIDEO SECURITY CAMERAS

A. Multiple types of Video Security Cameras shall be provided as shown in the contract drawings. All camera brands shall be a supported partner of the selected VMS and specific models shall be fully compatible. All new cameras shall meet or exceed the requirements outlined below:

1. Single sensor cameras

a. Single sensor cameras shall feature progressive scan CCD or CMOS color image sensor with a minimum resolution of 2.1 MP. Specific camera locations requiring higher resolution shall be identified in the contract drawings.
b. Capable of dual stream output.
c. Capable of H.265 video compression
d. Capable of frame rates of 30 frames per second (fps) or greater at full resolution.
e. Capable of orientation in hallway view mode.
f. Capable of horizontal field-of-view greater than 90°.
g. Acceptable Manufacturers:

1) Vivotek (V-Series)
2) Axis
3) Hanwha
4) Or approved equal

2. Multi-sensor cameras

a. Multi-sensor cameras shall contain a minimum of two (2) sensors and lenses.
b. Each sensor shall be progressive scan CCD or CMOS color image sensor with a minimum resolution of 3 MP. Specific camera locations requiring higher resolution shall be identified in the contract drawings.
c. Capable of dual stream output per sensor.
d. Capable of H.265 video compression
e. Capable of frame rates of 30 frames per second (fps) or greater at full resolution per sensor.
f. Capable of orientation in hallway view mode for all lenses.
g. Each lens shall be independently positionable.
h. Capable of lens orientation that allows a seamless image covering the intended field-of-view with no blind spot between the fields-of-view of any two adjacent lenses.
i. Acceptable Manufacturers:

1) Vivotek (V-Series)
2) Axis
3) Hanwha
4) Or approved equal

3. Contractor shall provide a memory card with each camera included in the project. Memory card shall meet the following requirements:

a. Format shall be as dictated by camera compatibility
b. Shall be rated for continuous recording and outdoor use.
c. Capacity shall be a minimum of 128GB.
d. If camera model will not support 128GB memory card, contractor shall provide the maximum capacity supported by the camera model.
e. Approved Manufacturers:

1) SanDisk
2) Samsung
3) Or approved equal

2.4 LONG RANGE PoE EXTENDERS

A. Contractor shall provide long range PoE extenders where required for camera locations which exceed the maximum distance specified in division 27.

B. PoE long range extenders shall be of the following Manufacturers:

1. Alltronix
2. NVT Phybridge
3. Veracity Longspan
4. Or approved alternative

2.5 WIRE AND CABLE

A. All wire and cable shall be Underwriter's Laboratories (UL) approved for its intended application, shall meet all national, state and local code requirements for its application, and shall meet or exceed manufacturers' recommendations for the components connected.

B. All wire and cable shall meet individual system or subsystem manufacturer specifications.

C. Wire and cable shall comply with the applicable requirements of the National Electrical Code (NEC), latest edition, in regards to cable construction and usage.

D. Insulation shall be rated for a minimum of 300 volts.

E. Provide exterior camera power wiring from each Telecom room location to the exterior camera locations if power supplies are used.

F. UTP cabling shall be provided and installed by the division 27 contractor.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of Authorities Having Jurisdiction.

B. All installation shall be in accordance with manufacturers' specifications and published recommendations.

C. Contractor shall review field-of-view for each camera sensor with the owner and make adjustments as required. Hallway/Corridor mode shall be utilized as noted in the drawings or as requested by the owner. Final field-of-view on all new camera views shall be approved by the owner.

D. Contractor shall configure and program all cameras to be fully functional within the owner's existing Video Management System. Coordinate with the owner to establish required settings for camera resolution, frame rate, compression formats and recording parameters.

E. Refer to division 27 specifications for all requirements related to cable and cable installation.

3.2 SYSTEM PROGRAMMING

A. The video security system shall be fully programmed per the Owner's requirements including but not limited to local area network configuration, NVR configuration, camera configuration, camera naming per LSSC standard conventions, VMS configuration, and interactive camera mapping. Contractor shall coordinate programming and configuration with the appropriate owner personnel.

3.3 SYSTEM ACCEPTANCE

A. Upon notification of project completion by the Contractor to the Project Manager, a final, on-site review of the system shall be conducted by representatives of the Contractor, Owner, and the Architect. All components and systems must be deemed by all parties to be acceptable prior to final system commissioning.

B. The Contractor shall provide two weeks advance notification to the Owner for scheduling of the final system acceptance.

C. The Contractor shall provide two copies of recorded drawings and in electronic format and two copies of completed testing/as built documents.

D. The Contractor shall provide in AutoCAD an electronic version of the recorded documents.

E. The Contractor shall provide the Project Manager, Field Supervisor and a Support Technician during the final system acceptance process for adequate support during the testing process.

F. The Contractor shall staff the Owners Monitoring Station to acknowledge alarms during the testing.

G. The Contractor shall accompany the Owner's Staff in the field to assist in the functional demonstration of security devices.

H. Punch list is developed and distributed by Architect and the Owner's Representative.

I. The Contractor shall produce documentation to demonstrate the punch list has been completed and the installation is at Final Completion.

J. Once the system has been accepted by the Owner, that date will be noted as the start of the warranty period. The Owner reserves the right to suspend and/or terminate testing at any time when the systems fails to perform as specified.

END OF SECTION 28 23 00

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Existing fire-alarm system to be modified.
2. Addressable fire-alarm system.
3. Fire-alarm control unit (FACU).
4. Manual fire-alarm boxes.
5. System smoke detectors.
6. Duct smoke detectors.
7. Fire-alarm notification appliances.
8. Fire-alarm remote annunciators.
9. Digital alarm communicator transmitters (DACTs).

B. Related Requirements:

1. Section 087100 "Door Hardware" for magnetic door holders that release in response to fire-alarm outputs.
2. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" or Section 260523 "Control Voltage Electrical Power Cables" for cables and conductors for fire-alarm systems.

1.2 284700DEFINITIONS

A. DACT: Digital alarm communicator transmitter.

B. FACU: Fire-alarm control unit.

C. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.3 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. When new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service.

1.4 ACTION SUBMITTALS

A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.

B. 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.

C. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, and details, including details of 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. Annunciator panel details as required by authorities having jurisdiction.
5. Detail assembly and support requirements.
6. Include voltage drop calculations for notification-appliance circuits.
7. Include battery-size calculations.
8. Include input/output matrix.
9. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
10. Include performance parameters and installation details for each detector.
11. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
12. Provide control wiring diagrams for fire-alarm interface to HVAC; 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 and equipment required for HVAC unit shutdown on alarm.
    c. Locate detectors in accordance with manufacturer's written instructions.
13. 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.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Qualification Statements: For Installer.

C. Sample Warranty: Submittal must include line item pricing for replacement parts and labor.

1.6 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:

a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Record copy of site-specific software.
g. Provide "Inspection and Testing Form" in accordance with "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.

h. Manufacturer's required maintenance related to system warranty requirements.
i. Abbreviated operating instructions for mounting at FACU and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media and approved online or cloud solution.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: 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 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.

4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Personnel must be trained and certified by manufacturer for installation of units required for this Project.
2. Installation must be by personnel certified by NICET as fire-alarm Level II technician.
3. Obtain certification by NRTL in accordance with NFPA 72.
4. Licensed or certified by authorities having jurisdiction.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 EXISTING FIRE-ALARM SYSTEM TO BE MODIFIED

A. Basis for Pricing: Siemens.

B. Source Limitations for Fire-Alarm System and Components: Components must be compatible with, and operate as extension of, existing system. Provide system manufacturer's certification that components provided have been tested as, and will operate as, a system.

2.2 ADDRESSABLE FIRE-ALARM SYSTEM

A. Description:

1. Noncoded, UL-certified addressable system, with multiplexed signal transmission and **horn** and-strobe notification for evacuation.

B. Performance Criteria:

1. Regulatory Requirements:

a. Fire-Alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 70 for use with selected fire-alarm system and marked for intended location and application.

2. General Characteristics:

a. Automatic sensitivity control of certain smoke detectors.
b. Fire-alarm signal initiation must be by one or more of the following devices:

1) Manual stations.
2) Smoke detectors.
3) Duct smoke detectors.
4) Automatic sprinkler system water flow.
5) Preaction system.
6) Fire-extinguishing system operation.
7) Fire standpipe system.
8) Dry system pressure flow switch.
9) Fire pump running.

c. Fire-alarm signal must initiate the following actions:

1) Continuously operate alarm notification appliances.
2) Identify alarm and specific initiating device at FACU, connected network control panels, off-premises network control panels, and remote annunciators.
3) Transmit alarm signal to remote alarm receiving station.
4) Unlock electric door locks in designated egress paths.
5) Release fire and smoke doors held open by magnetic door holders.
6) Activate voice/alarm communication system.
7) Switch HVAC equipment controls to fire-alarm mode.
8) Activate stairwell and elevator-shaft pressurization systems.
9) Close smoke dampers in air ducts of designated air-conditioning duct systems.
10) Activate preaction system.
11) Recall elevators to primary or alternate recall floors.
12) Activate elevator power shunt trip.
13) Activate emergency lighting control.
14) Record events in system memory.
15) Indicate device in alarm on graphic annunciator.

d. Supervisory signal initiation must be by one or more of the following devices and actions:

1) Valve supervisory switch.
2) High- or low-air-pressure switch of dry-pipe or preaction sprinkler system.
3) Elevator shunt-trip supervision.
4) Independent fire-detection and -suppression systems.
5) Fire pump is running.
6) Fire pump has lost power.
7) Power to fire pump has phase reversal.
8) Zones or individual devices have been disabled.
9) FACU has lost communication with network.

e. System trouble signal initiation must 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 addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4) Loss of primary power at FACU.
5) Ground or single break in internal circuits of FACU.
6) Abnormal ac voltage at FACU.
7) Break in standby battery circuitry.
8) Failure of battery charging.
9) Abnormal position of switch at FACU or annunciator.
10) Voice signal amplifier failure.
11) Hose cabinet door open.

f. System Supervisory Signal Actions:

1) Initiate notification appliances.
2) Identify specific device initiating event at FACU, connected network control panels, off-premises network control panels, and remote annunciators.
3) Record event on system printer.
4) After time delay of 200 seconds, transmit trouble or supervisory signal to remote alarm receiving station.
5) Transmit system status to building management system.
6) Display system status on graphic annunciator.

g. Network Communications:

1) Provide network communications for fire-alarm system in accordance with fire-alarm manufacturer's written instructions.
2) Provide network communications pathway per manufacturer's written instructions and requirements in NFPA 72 and NFPA 70.
3) Provide integration gateway using BACnet for connection to building automation system.

h. Device Guards:

1) Description: Welded wire mesh of size and shape for manual station, smoke detector, gong, or other device requiring protection.

a) Factory fabricated and furnished by device manufacturer.
b) Finish: Unless otherwise noted, paint of color to match protected device.

i. Document Storage Box:

1) Description: Enclosure to accommodate standard 8-1/2-by-11 inch manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key contacts, and system information. Provide two

key ring holders with location to mount standard business cards for key contact personnel.

2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
3) Color: Red powder-coat epoxy finish.
4) Labeling: Permanently screened with 1 inch high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
5) Security: Locked with 3/4 inch barrel lock. Provide solid 12 inch stainless steel piano hinge.

2.3 FIRE-ALARM CONTROL UNIT (FACU)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Notifier; Honeywell International, Inc.
2. Siemens Industry, Inc., Building Technologies Division.
3. Simplex; brand of Johnson Controls International plc, Building Solutions North America.

B. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.

C. Performance Criteria:

1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
2. General Characteristics:

a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
b. Include real-time clock for time annotation of events on event recorder and printer.
c. Provide communication between FACU and remote circuit interface panels, annunciators, and displays.
d. FACU must be listed for connection to central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACU must provide minimum 500-event history log.
f. Addressable Initiation Device Circuits: FACU must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.

1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACU must be listed for releasing service.

g. Fire-Alarm Annunciator: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

1) Annunciator and Display: LCD, 80 characters, minimum.
2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.

h. Alphanumeric Display and System Controls: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

1) Annunciator and Display: LCD, two line(s) of 40 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 system for control of smoke-detector sensitivity and other parameters.

i. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1) Pathway Class Designations: NFPA 72, Class B.
2) Pathway Survivability: Level 0.
3) Install no more than 50 addressable devices on each signaling-line circuit.
4) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.

j. Serial Interfaces:

1) One dedicated RS 485 port for central-station operation using point ID DACT.
2) One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
3) One USB port for PC configuration.
4) One RS 232 port for air-aspirating smoke detector connection.
5) One RS 232 port for voice evacuation interface.

k. Stairwell Pressurization: Provide output signal using addressable relay to start stairwell pressurization system. Signal must remain on until alarm conditions are cleared and fire-alarm system is reset. Signal must not stop in response to alarm acknowledge or signal silence commands.

1) Pressurization starts when alarm is received at FACU.
2) Alarm signals from smoke detectors at pressurization air supplies have higher priority than other alarm signals that start system.

l. Smoke-Alarm Verification:

1) Initiate audible and visible indication of "alarm-verification" signal at FACU.
2) Activate approved "alarm-verification" sequence at FACU and detector.
3) Sound general alarm if alarm is verified.
4) Cancel FACU indication and system reset if alarm is not verified.

m. Notification-Appliance Circuit:

1) Audible appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
2) Where notification appliances provide signals to sleeping areas, alarm signal must be 520 Hz square wave with intensity 15 dB above average ambient sound level or

5 dB above maximum sound level, or at least 75 dB(A-weighted), whichever is greater, measured at pillow.

3) Visual alarm appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.

n. Elevator Recall: Initiate by one of the following alarm-initiating devices:

1) Elevator lobby detectors except lobby detector on designated floor.
2) Smoke detectors in elevator machine room.
3) Smoke detectors in elevator hoistway.

o. Elevator controller must be programmed to move cars to alternate recall floor if lobby detectors located on designated recall floors are activated.

p. Water-flow alarm connected to sprinkler in elevator shaft and elevator machine room must shut down elevators associated with location without time delay.

1) Water-flow switch associated with sprinkler in elevator pit may have delay to allow elevators to move to designated floor.

q. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls mustbe connected to fire-alarm system.

r. Remote Smoke-Detector Sensitivity Adjustment: Controls must 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 final adjusted values on system printer.

s. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to remote alarm station.

t. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of central-control microphone. Amplifiers must comply with UL 1711.

1) Allow application of, and evacuation signal to, indicated number of zones and simultaneously allow voice paging to other zones selectively or in combination.
2) Programmable tone and message sequence selection.
3) Standard digitally recorded messages for "Evacuation" and "All Clear."
4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of FACU.

u. Status Annunciator: Indicate status of various voice/alarm speaker zones and status of firefighters' two-way telephone communication zones.

v. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.

w. Primary Power: 24 V(dc) obtained from 120 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, and supervisory signals supervisory and DACT must be powered by 24 V(dc) source.

x. Alarm current draw of entire fire-alarm system must not exceed 80 percent of power-supply module rating.

y. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch.
z. Batteries: Sealed lead calcium.

D. Accessories:

1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.
2. Preaction System Functionality:

a. Initiate Presignal Alarm: This function must cause audible and visual alarm and indication to be provided at FACU. Activation of initiation device connected as part of preaction system must be annunciated at FACU only, without activation of general evacuation alarm.

2.4 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Notifier; Honeywell International, Inc.
2. Siemens Industry, Inc., Building Technologies Division.
3. Simplex; brand of Johnson Controls International plc, Building Solutions North America.

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must 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 alarm, breaking-glass or plastic-rod pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACU.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm.
5. Able to perform at up to 90 percent relative humidity at 90 deg F.
6. Material: Manual stations made of Lexan polycarbonate.
7. Able to be used in indoor or outdoor areas.

2.5 SYSTEM SMOKE DETECTORS

A. Photoelectric Smoke Detectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Notifier; Honeywell International, Inc.
b. Siemens Industry, Inc., Building Technologies Division.
c. Simplex; brand of Johnson Controls International plc, Building Solutions North America.

2. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.
2) UL 268.

b. General Characteristics:

1) Detectors must be four-wire type.
2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
3) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5) Integral Visual-Indicating Light: LED type, indicating detector has operated.
6) Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
7) Operator at FACU, having designated access level, must 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.).

8) Detector must have functional humidity range within 10 to 90 percent relative humidity.
9) Color: White.
10) Remote Control: Unless otherwise indicated, detectors must be digital-addressable type, individually monitored at FACU for calibration, sensitivity, and alarm condition.
11) Rate-of-rise temperature characteristic of combination smoke- and heat-detection units must be selectable at FACU for 15 or 20 deg F per minute.
12) Fixed-temperature sensing characteristic of combination smoke- and heat-detection units must be independent of rate-of-rise sensing and must be settable at FACU to operate at 135 or 155 deg F.
13) Multiple levels of detection sensitivity for each sensor.
14) Sensitivity levels based on time of day.

2.6 DUCT SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Notifier; Honeywell International, Inc.
2. Siemens Industry, Inc., Building Technologies Division.
3. Simplex; brand of Johnson Controls International plc, Building Solutions North America.

B. Description: Photoelectric-type, duct-mounted smoke detector.

C. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.
b. UL 268A.

2. General Characteristics:

a. Detectors must be four-wire type.
b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
d. Integral Visual-Indicating Light: LED type, indicating detector has operated.
e. Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
f. Operator at FACU, having designated access level, must be able to manually access the following for each detector:

1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).

g. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with supplied detector for smoke detection in HVAC system ducts.
h. Each sensor must have multiple levels of detection sensitivity.
i. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
j. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 FIRE-ALARM REMOTE ANNUNCIATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Notifier.
2. Siemens.
3. Simplex.

B. Performance Criteria:

1. Regulatory Requirements:

   a. NFPA 72.

2. General Characteristics:

   a. Annunciator functions must match those of FACU for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACU, including acknowledging, silencing, resetting, and testing.

      1) Mounting: Flush cabinet, NEMA 250, Type 1.

   b. Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of FACU. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.8 DIGITAL ALARM COMMUNICATOR TRANSMITTERS (DACTs)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Notifier.
2. Siemens.
3. Simplex.

B. Performance Criteria:

1. Regulatory Requirements:

   a. NFPA 72.

2. General Characteristics:

   a. DACT must be acceptable to remote central station and must be listed for fire-alarm use.
   b. Functional Performance: Unit must receive alarm, supervisory, or trouble signal from FACU and automatically capture one telephone line(s) and dial preset number for remote central station. When contact is made with central station(s), signals must be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter must initiate local trouble signal and transmit signal indicating loss of telephone line to remote alarm receiving station over remaining line. Transmitter must automatically report telephone service restoration to central station. If service is lost on both telephone lines, transmitter must initiate local trouble signal.
   c. Local functions and display at DACT must 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 central station or FACU.
      6) .

d. Digital data transmission must include the following:

1) Address of alarm-initiating device.
2) Address of supervisory signal.
3) Address of trouble-initiating device.
4) Loss of ac supply.
5) Loss of power.
6) Low battery.
7) Abnormal test signal.
8) Communication bus failure.
9) .

e. Secondary Power: Integral rechargeable battery and automatic charger.
f. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

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 PREPARATION

A. Preinstallation Testing: Perform verification of functionality of installed components of existing system prior to starting work. Document equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service in accordance with requirements indicated:

1. Notify Owner no fewer than days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

C. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.3 INSTALLATION OF EQUIPMENT

A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install 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 other trades have completed cleanup must be replaced.
2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of building.
2. Connect new equipment to existing monitoring equipment at supervising station.
3. Expand, modify, and supplement existing control monitoring equipment as necessary to extend existing control monitoring functions to new points. New components must be capable of merging with existing configuration without degrading performance of either system.

C. 033000270548270548Install wall-mounted equipment, with tops of cabinets not more than 78 inch above finished floor.

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in normal path of egress within 60 inch of exit doorway.
2. Mount manual fire-alarm box on background of contrasting color.
3. Operable part of manual fire-alarm box must be between 42 and 48 inch above floor level. Devices must be mounted at same height unless otherwise indicated.

E. Smoke- and Heat-Detector Spacing:

1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing must not exceed 30 ft..
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex A in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inch from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inch from lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install cover on each smoke detector that is not placed in service during construction. Cover must 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 full width of duct. Tubes more than 36 inch long must 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. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inch below ceiling. Install bells and horns on flush-mounted back boxes with device-operating mechanism concealed behind grille. Install devices at same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inch below ceiling. Install devices at same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near device they monitor.

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 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate must be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least 1/2 inch high.

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."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 PATHWAYS

A. Pathways above recessed ceilings and in inaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inch above floor must be installed in EMT.

B. Pathways must be installed in EMT.

C. Exposed EMT must be painted red enamel.

3.7 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 supervised interface device to the following devices and systems. Install interface device less than 36 inch from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.
1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Supervisory connections at valve supervisory switches.
7. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
8. Supervisory connections at elevator shunt-trip breaker.
9. Supervisory connections at fire-pump power failure including dead-phase or phase-reversal condition.
10. Supervisory connections at fire-pump engine control panel.
11. .

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in location visible from FACU.

3.9 GROUNDING

A. Ground FACU and associated circuits in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.10 FIELD QUALITY CONTROL

A. Field tests must be witnessed by authorities having jurisdiction.

B. Administrant for Tests and Inspections:

1. Owner will engage qualified testing agency to administer and perform tests and inspections.
2. Engage qualified testing agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

   a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
   b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.

2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
4. Test audible appliances for private operating mode in accordance with manufacturer's written instructions.
5. Test visible appliances for public operating mode in accordance with manufacturer's written instructions.
6. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. 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.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

3.12 MAINTENANCE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections in accordance with "Visual Inspection Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in "Test Methods" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per "Testing Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.13 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement must include software support for two years.

C. 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 must include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

END OF SECTION 284621.11

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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. Protecting existing trees and grass to remain.
2. Removing existing trees, shrubs, groundcovers, plants, and grass.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping or sealing, and removing site utilities.

B. Related Sections:

1. Division 31 Section “Earth Moving” for soil materials, excavating, backfilling, and site grading.

1.3 DEFINITIONS

A. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 1 inch in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

B. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference to comply with requirements in Division 1.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

B. Tree Protection Fence: 6’ high medium duty chain link or as otherwise indicated.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TREE PROTECTION

A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.

1. Do not store construction materials, debris, or excavated material within fenced area.
2. Do not permit vehicles, equipment, or foot traffic within fenced area.
3. Maintain fenced area free of weeds and trash.

B. Do not excavate within tree protection zones, unless otherwise indicated.

C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

1. Cover exposed roots with burlap and water regularly.
2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
3. Coat cut faces of roots, more than 1-1/2 inches in diameter, with emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
4. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.

1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
2. Replace trees that cannot be repaired and restored to full-growth status. Replacement tress shall have a total cumulative caliper dimension equal two times the caliper dimension of the damaged tree. The minimum size of the replacement trees is to be 2-1/2 inch caliper.

3.3 UTILITIES

A. Arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing.

1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities.
2. Owner will arrange to shut off indicated utilities when requested by Contractor.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

E. Excavate for and remove underground utilities indicated to be removed.

F. Locate all existing utilities in construction areas as per Section 017300; Execution.

3.4 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
3. Use only hand methods for grubbing within protection zones.
4. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct instillation of new construction.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove sod and grass, cornstalks and other vegetative material before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.
2. Provide dust control measures as per other Sections.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to 12 feet or as otherwise directed by Engineer.
2. Do not stockpile topsoil within protection zones.
3. Dispose of surplus topsoil.
4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Unless specified otherwise remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Preparing subgrades for slabs-on-grade, walks, pavements, and lawns.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for slabs-on-grade.
4. Subbase course for concrete walks and pavements.
5. Base course for asphalt paving.
6. Subsurface drainage backfill for pavements.
7. Excavating and backfilling trenches within building lines.
8. Excavating and backfilling trenches for buried utilities and pits for buried utility structures.

B. Related Sections include the following:

1. Division 01 Section “Surface Water, Erosion, and Sediment Control.”
2. Division 01 Section “Construction Progress Documentation.”
3. Division 01 Section "Construction Facilities and Temporary Controls."
4. Division 03 Section "Cast-in-Place Concrete for granular course if placed over vapor retarder and beneath the slab-on-grade
5. Divisions 21, 22, 23, 26, 27, 28, and 33 Sections for installing underground mechanical and electrical utilities and buried mechanical and electrical structures.
6. Division 31 Section "Site Clearing" for site stripping, grubbing, removing topsoil, and protecting trees to remain.
7. Division 31 Section "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
8. Division 31 Section "Finish Grading" for preparation, testing, placement, and finish grading of topsoil for lawns and plantings.
9. Division 31 Section “Excavation and Fill” for trench work.
10. Division 31 Section "Site Clearing" for site stripping, grubbing, removing topsoil, and protecting trees to remain.
11. Division 32 Section "Turf and Grasses" for preparation, testing, placement, and finish grading of topsoil for lawns and plantings.

1.3 PROFORMANCE REQUIREMENTS

A. Excavation is unclassified. All rock removal associated with this project shall be included in the Base Bid. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions with the exception of requested changes effectuated through a Change of Scope Directive.

1.4 DEFINITIONS

A. Backfill: Soil materials used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench to final grade elevation.

B. Base Course: Layer placed between the subbase course and asphalt paving.

C. Bedding Course: Layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Layer supporting slab-on-grade used to minimize capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations.

1. Bulk Excavation: Excavations more than 10 feet in width and pits more than 30 feet in either length or width.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Rock: Rock material in beds, ledges, unstratified masses, and conglomerate deposits and boulders of rock material 3/4 cu. yd. or more in volume that when tested by an independent geotechnical testing agency, according to ASTM D 1586, exceeds a standard penetration resistance of 100 blows/2 inches.

I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

J. Subbase Course: Layer placed between the subgrade and base course for asphalt paving, or layer placed between the subgrade and a concrete pavement or walk.

K. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

L. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

M. INDOTSS: Indiana Department of Transportation Standard Specifications.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Each type of plastic warning tape.
2. Drainage fabric.
3. Aggregate.

B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 698 for each on-site or borrow soil material proposed for fill and backfill.

1.6 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

B. Pre-excavation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination.

1.7 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.
3. Contact utility-locator service for area where Project is located before excavating.

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

C. Project-Site Information: A geotechnical report has been prepared for this Project and it is included for information only. The opinions expressed in this report are those of the geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by the geotechnical engineer.

1. Owner will not be responsible for interpretations or conclusions drawn from geotechnical data.
2. The geotechnical report is provided elsewhere in the Project Manual. Refer to "Table of Contents" for location.

PART 2 – PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: ASTM D 2487 soil classification groups GW, GP, GM, SW, SP, and SM, or a combination of these group symbols; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: ASTM D 2487 soil classification groups GC, SC, ML, MH, CL, CH, OL, OH, and PT, or a combination of these group symbols.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
2. Unsatisfactory soils may be used if they are properly conditioned and determined acceptable for their intended use through field observation by the Geotechnical Engineer.

D. Backfill and Fill: Satisfactory soil materials or those unsatisfactory soils determined acceptable by the Geotechnical Engineer.

E. Base: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve. INDOTSS #53.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

G. Bedding: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve. INDOTSS #11 or #12.

H. Underslab Drainage Fill: Washed, narrowly graded mixture of natural or crushed gravel, crushed stone, or crushed or uncrushed gravel; ASTM D448; with at least 90 percent passing a 1-inch sieve and not more than 15 percent passing a No. 200 sieve. INDOTSS #53.

I. Drainage Fill: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 8; with 100 percent passing a 1/2- inch sieve and 0 to 5 percent passing a No. 8 sieve. INDOTSS #8.

J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.

K. Structural Fill: Any fill which will support structural loads that as determined to be acceptable by the Geotechnical Engineer. The fill shall be clean and free of organic material, debris, deleterious materials and frozen soils. Samples of the proposed fill materials shall be tested by the Geotechnical Engineer prior to initiation of earthwork and backfilling operations to determine the classification, the natural and optimum moisture content and maximum dry density, and overall stability as a structural fill.

2.2 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, minimum 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 as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

B. Drainage Fabric: Nonwoven geotextile, specifically manufactured as a drainage geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:

1. Acceptable Manufacturers:
a. Propex
b. Approved Equal
2. Referenced Products to match or exceed the standards of the Propex Geotex:
a. Geotex 801
b. Approved Equal
3. Minimum Properties:
a. Grab Tensile Strength: 205 lbf; ASTM D 4632.
b. Tear Strength: 80 lbf; ASTM D 4533.
c. Puncture Resistance: 525 lbf; ASTM D 4833.
d. Water Flow Rate: 110 gpm per sq. ft.; ASTM D 4491.
e. Apparent Opening Size: No. 80; ASTM D 4751.

PART 3 – EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

C. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain dewatering continuously as required until no longer required.

3.3 EXPLOSIVES

A. Explosives: Use of explosives will not be permitted.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions with the exception of effectuated through a Change of Scope Directive.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

    a. The Geotechnical Engineer may permit machine excavation, if a bucket with a straight edge blade or “strike-off-plate” is used and the bearing capacity of the soils is not disturbed. Obtained written approval before starting work.

2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended for bearing surface.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of pipe to indicated design elevations and top of pipe a minimum depth of 36” below finished elevation, including electrical pipe.

B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: As indicated.

C. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.8 APPROVAL OF SUBGRADE

A. Notify Owner’s Representative and Architect when excavations have reached required subgrade.

B. If Owner’s Representative, Architect Engineer and/or Geotechnical Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

1. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

C. Proof roll subgrade with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof roll wet or saturated subgrades. Geotech is required to witness all proof-rolling activities and submit a report.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, Geotech or Owner's Representative and replace with compacted backfill or fill as directed.

D. In lieu of proof rolling within the footprint of the building, the Testing Agent may, with approval of Owner's Representative and Architect, perform necessary testing utilizing appropriate and acceptable methods to determine and certify bearing capacity of subgrade.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation.

1. Fill unauthorized excavations under other construction or utility pipe as directed by Architect.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow materials and satisfactory excavated soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly at lifts no greater than 4", but not before completing the following:

1. Construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for record documents.
3. Inspecting and testing underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.

7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

3.12 UTILITY TRENCH BACKFILL

A. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

B. Place and compact initial approved backfill as indicated, free of particles larger than 1 inch, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact approved material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.

C. Coordinate backfilling with utilities testing.

D. Fill voids with approved backfill materials while shoring and bracing, and as sheeting is removed.

E. Place and compact final backfill of satisfactory soil material as indicated to final subgrade.

F. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

G. All utility trenches under all pavement and 4’ beyond edge of pavement shall be backfilled with compacted #53 stone in lifts no greater than 4”. All engineered fill shall be tested for proper compaction. If #8, #11 or #12 stone is approved to be utilized for backfill material, fill material shall still be compacted. When #8, #11, #12 stone is approved and utilized, the top 12” of stone to final grade shall be compacted #53 stone.

3.13 FILL

A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface and proof roll, under the observation and direction of the Geotechnical Engineer, to identify soft pockets and areas of excessive yielding. If Architect/Geotechnical Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted approved backfill or fill material as directed. Additional excavation and replacement material will be compensated according to contract provisions for changes in the work.

B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

C. Place and compact approved fill material in layers and lifts no greater than 6” to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.

2. Under walks and pavements, use engineered fill, and/or approved structural fill.
3. Under steps and ramps, use engineered fill, and/or structural fill.
4. Under building slabs, use engineered fill, and/or structural fill.
5. Under footings and foundations, use engineered fill, and/or structural fill.

3.14 MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF BACKFILLS AND FILLS

A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil to not less than the following percentages of maximum dry unit weight according to ASTM D-698; Standard Proctor compaction test.

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill material at 95 percent.
2. Under footings and foundations requiring additional excavation, compact each layer of fill material to98 percent maximum dry density.
3. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material at 95 percent.
4. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material at 85 percent.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1/2 inch.
2. Walks: Plus or minus 1/8 inch.
3. Pavements: Plus or minus 1/8 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.17 SUBBASE AND BASE COURSES

A. Under pavements and walks, place subbase course on prepared subgrade and as follows:

1. Place base course material over subbase.
2. Compact subbase and base courses at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D-698.
3. Shape subbase and base to required crown elevations and cross-slope grades.
4. When thickness of compacted subbase or base course is 6 inches or less, place materials in a single layer.
5. When thickness of compacted subbase or base course exceeds 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

3.18 UNDERSLAB DRAINAGE COURSE

A. Under slabs-on-grade, place underslab drainage fill on prepared subgrade and as follows:

1. Compact drainage course to required cross sections and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D-698.
1. When compacted thickness of drainage course is 6 inches or less, place materials in a single layer.
2. When compacted thickness of drainage course exceeds 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

3.19 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency acceptable to the Owner, Architect, and Engineer to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be

based on a visual comparison of subgrade with tested subgrade when approved by Architect/Geotechnical Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 1000 sq. ft. or less of paved area or building slab, but in no case fewer than six tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for each 100 feet or less of wall length, but no fewer four two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for each 150 feet or less of trench length, but no fewer than four tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 312000

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Place, finish grade and compact topsoil.
2. Replenish topsoil in areas where clearing has been completed and not scheduled to receive new base course material.

B. Related Sections include the following:

1. Division 31 Section "Earth Moving"
2. Division 32 Section "Turf and Grasses" for finish grading, including placing, preparing and testing topsoil for lawns.

C. Protection

1. Prevent damage to existing features. Correct damage at no cost to owner.

1.2 QUALITY ASSURANCE

A. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

B. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

1. Report suitability of topsoil for lawn growth. State-recommended quantities of nitrogen, phosphorous, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Existing topsoil on site: Existing topsoil shall be removed where advantageous. This soil may be reused for lawns and plantings provided that it meets the topsoil requirements as specified below.

B. Topsoil: Friable loam, free from subsoil, roots, grass, excessive amount of weeds, stones and foreign matter. Acidity range of 5.5 to 7.0 pH. Topsoil shall contain a minimum of 6% and a maximum of 25% organic matter and soluble salts shall not be higher than 500 parts per million.

C. Lime: Lime shall be ground limestone containing not less than 85% of total carbonates and shall be ground so that 50% will pass through the100-mesh sieve and 90% will pass through the 20-mesh sieve.

PART 3 – EXECUTION

3.1 SUBSOIL PREPARATION

A. Rough grade subsoil systematically to allow for maximum amount of settlement and compaction. Eliminate uneven areas and low spots. Remove debris, roots, branches, stones, etc. Remove subsoil which has been contaminated with petroleum products.

B. Excavate and fill where necessary to bring subgrade to required levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

C. Cultivate subgrade to a depth of 6” where topsoil is to be placed. Repeat cultivation in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

D. Compact materials to meet the following minimum percentages of modified proctor density, ASTM D1557, method C or D. Compact subsoil to the following:

1. 88% where topsoil is to be placed.
2. 95% where stabilizing base for pavements are to be placed

3.2 PLACING TOPSOIL

A. Use topsoil in a relatively dry state and place during dry weather.

B. Fine grade topsoil eliminating rough or low areas to ensure positive site drainage. Maintain levels, profiles, and contours of subgrade.

C. Remove stones, roots, grass, weeds, debris and foreign material while spreading.

D. Manually spread topsoil within tree drip lines to prevent damage caused by grading equipment.

E. Lightly compact placed topsoil.

3.3 SURPLUS MATERIAL

A. Remove surplus subsoil and topsoil from site.

B. Leave stockpile areas and entire job site clean and raked, ready to receive landscaping.

END OF SECTION 312219

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section lists methods and materials for trench excavation and backfill for water, sanitary sewer, and storm sewer encountered outside the building.

1.2 RELATED WORK

A. Division 31 Section “Earth Moving”.

B. Division 31 Section “Excavation Support and Protection.”

1.3 REFERENCE

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions of the Contract, Supplementary Conditions, and sections under Division 1 General Requirements.

1.4 SUBMITTALS

A. List of materials to be used for backfill, including gradation and source.

PART 2 - PRODUCTS

2.1 FILL MATERIAL

A. Contractor shall obtain and pay for all costs to obtain proctors of proposed soils if approved and anticipated to be utilized for fill.

B. Backfill and Fill: Satisfactory soil materials.

1. Liquid limit: 35% maximum in accordance with ASTM D432.
2. Plasticity index: 12% maximum in accordance with ASTM D424.
3. Sieve analysis: 25% maximum by weight passing No. 200 sieve in accordance with ASTM D1140.

C. Base: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 100 percent passing a 1-1/2 inches sieve and not more than 10 percent passing a No. 200 sieve.

1. INDOTSS: 904.02; Type 'O' No. 53 coarse aggregate.

D. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, natural or crushed sand; ASTM D 2940; with at least 100 percent passing a 1-1/2 inches sieve and not more than 10 percent passing a No. 200 sieve.

1. INDOTSS: 904.02; Type 'O' No. 53 coarse aggregate.

E. Bedding "C": Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, natural or crushed sand; ASTM D 2940; with at least 100 percent passing a 1/2 inch sieve and not more than 10 percent passing a No. 8 sieve.

1. INDOTSS: 904.02; No. 11 or No. 12 coarse aggregate.

F. Drainage Fill for underground detention facility: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 8; with 100 percent passing a 1/2- inch sieve and 0 to 5 percent passing a No. 8 sieve. INDOTSS #8.

PART 3 - EXECUTION

3.1 PREPARATION

A. Establish grade lines and locations of mains and manholes. Provide necessary stakes and batter boards.

B. Verify invert elevations of existing utilities prior to excavation for new utility piping.

3.2 EXCAVATION

A. Provide excavation for all underground work, including but not limited to piping, casings, and cast-in-place concrete structures unless otherwise shown or specified. Lay piping in open trench unless indicated otherwise or when Engineer gives written permission for tunneling.

B. Include all necessary clearing; tree removal; grubbing; pavement removal; substructure removal such as walls, footings and piers, and all incidental work such as tunneling, sheet piling, shoring, underpinning, pumping, bailing, and transportation. Excavation can extend beyond construction limits.

C. Blasting is not allowed on this project.

D. Remove all excess excavation material from site, unless directed otherwise.

3.3 INSTALLATION

A. Keep underground piping to proper line and grade and sealed at all times to prevent entrance of animals or foreign matter.

B. Provide bracing and sheet piling as necessary to support trenches. Comply with local regulations, applicable provisions of OSHA regulations on trenching, or with provisions of "Manual of Accident Prevention in Construction" published by Associated General Contractors of America. Under no circumstances lay pipe or install appurtenances in water. Keep trench free from water until pipe joint material has hardened. Presence of ground water in soil or necessity of sheet piling or bracing trenches shall not constitute condition for which any increase may be made in Contract price, except, when sheet piling is left in place on written order of Owner, Contract price will be adjusted.

C. Cut off sheet piling left in place not less than 2-inches below new finished grade. Do not remove sheet piling until trench is substantially backfilled.

D. Place underground piping outside building on 4-inches or 6-inches on rock on compacted bedding of INDOTSS #11 or #12 stone. Shape bedding for clearance for all joints and fittings, tamped in place and graded evenly to insure uniform bearing for full length of pipe. Do not support piping by blocking, planking or mounding of bedding material.

3.4 BACKFILL

A. Backfill outside building including all piping beyond construction limits only after piping and appurtenances have been inspected, recorded, tested and approved. Backfill around pipe by hand to depth of 12-inches above top of pipe, unless shown otherwise, with INDOTSS #11 or #12 stone. Take care not to disturb pipe or damage pipe coating. Compact backfill thoroughly with compactor of suitable weight or with approved mechanical tamper. No flooding or jetting with water is allowed.

B. In yard areas place backfill from 12-inches above pipe, unless shown otherwise, in layers not exceeding 8-inches in depth with satisfactory approved fill. Compact backfill material to the same density as surrounding area prior to that of excavation.

C. When excavating through areas and four feet beyond pavement edges that are to become walks, roads, driveways or parking areas of concrete, bituminous, or exposed gravel surfacing, or such areas are existing to remain; backfilling from 12-inches above pipe, unless shown otherwise, to subgrade shall be with INDOTSS #53 stone. Backfill in 8-inch layers and compact with mechanical means to density 95 percent standard proctor according to ASTM D-698. Frequency of compaction testing shall be determined by testing consultant, based on site conditions, materials, and workmanship.

D. When excavation occurs on public property or areas beyond property line, all excavation, pipe laying, backfilling, grading, and surfacing shall conform as herein specified, except additional requirements for public utility or other authorities shall be complied with when in order.

3.5 ROCK EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for details.

B. Excavate rock to 6-inches below bottom of pipe, fittings, conduit systems, casings, and concrete structures unless specifically indicated otherwise.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: All Testing shall be performed by Patriot Engineering. All costs for testing shall be by Contractor in accordance with the General Provisions.

3.7 FINISHING

A. On completion of trenching and backfilling operations, restore grades to original elevation or to new subgrade elevation. When trenching is through existing areas or beyond constructions limits, replace surfaces to existing conditions or better.

B. In landscaped areas use a minimum of 6-inches of topsoil and sod to match existing elevations.

END OF SECTION 312300

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes temporary excavation support and protection systems.

B. Related Sections include the following:

1. Division 31 Section "Earth Moving" for excavating and backfilling, dewatering, and existing utilities.

1.3 PERFORMANCE REQUIREMENTS

A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.

1. Provide professional engineering services needed to assume engineering responsibility, including preparation of Shop Drawings and a comprehensive engineering analysis by a qualified professional engineer.
2. Prevent surface water from entering excavations by grading, dikes, or other means.
3. Install excavation support and protection systems without damaging existing buildings, pavements, and other improvements adjacent to excavation.

1.4 SUBMITTALS

A. Shop Drawings for Information: Prepared by or under the supervision of a qualified professional engineer for excavation support and protection systems.

1. Include Shop Drawings signed and sealed by the qualified professional engineer responsible for their preparation.

B. Qualification Data: For Installer and professional engineer.

C. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by the absence of, the installation of, or the performance of excavation support and protection systems.

1.5 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Engineer and then only after arranging to provide temporary utility services according to requirements indicated.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.
2. The geotechnical report is included elsewhere in the Project Manual.

C. Survey adjacent structures and improvements, employing a qualified professional engineer or land surveyor; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of 4 inches, or as otherwise required.

E. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

F. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.
2. Shore, support, and protect structures, buildings, and site features to remain.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces is not impeded.

D. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.2 SOLDIER BEAMS AND LAGGING

A. Install steel soldier beams before starting excavation. Space soldier beams at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier beams as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at centers indicated and secure to soldier beams.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Tiebacks: Drill for, install, grout, and tension tiebacks into position. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Test loading shall be observed by a qualified professional engineer responsible for design of excavation support and protection system.
2. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.5 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work, unless otherwise approved by Architect.
2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlying construction and abandon remainder.
2. Repair or replace, as approved by Engineer, adjacent work damaged or displaced by removing excavation support and protection systems.

END OF SECTION 315000

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. The extent of artificial turf work is shown on the drawings.

1. Artificial turf work includes, but is not limited to, the following: The installation of all new materials shall be performed in strict accordance with these specifications, the manufacturer's instructions and in accordance with all details and shop drawings.

a. Coordination with related trades to ensure a complete, integrated, and timely installation.
b. Field and markings to comply with NFHS rules and regulations.

B. SUMMARY

1. A complete synthetic turf system, consisting of slit film and thatch with a urethane backing. Pile height of .75 inches..

2. Tufted-in game lines and perimeter lines per drawings. Remaining required game markings shall be permanently inlaid or painted as per drawings; direction of Owner or Owner's Representative.

3. Edge details.

4. Maintenance manual.

5. Written company warranty: 8-year manufacture warranty supported by an independent 3rd party insured 8-year warranty policy from an A-Rated domestic insurance carrier. The 8-year warranty is to include the entire system. Letters of credit are not permissible. Insured warranty must provide for $15,000,000 aggregate and
$10,000,000 "per claim" coverage per year for the 8 year warranty period. Letters of Credit, warranty coverage from a "related party" company or financial statements of the turf company will not be accepted in lieu of the true third party insured warranty.

6. Striping and seaming plan: Striping plan; layouts for the sports as shown on the drawings showing any field lines, logos, markings, and boundaries.
7. Train field maintenance personnel in proper care maintenance procedures.

C. Provide all materials, labor, equipment, and services required to accomplish related work in accordance with the drawings and specifications.

D. The artificial turf shall be specifically designed, manufactured, and installed for the intended sports and events. Typically, sports include, but are not limited to, football, soccer, lacrosse,

field hockey, baseball, and softball. At the time of substantial completion, the system's shock attenuation shall have an average G-max value less than 125 at time of installation, based on ASTM-F355A. At no time shall the G-max value exceed 175 throughout the life of the warranty.

E. Copies of independent laboratory test reports on system or components:

1. ASTM D 792 Specific Gravity
2. ASTM D 1335 Tuft Bind
3. ASTM D 5034 Grab Breaking Strength
4. ASTM D 418 Pile Height, Tuft Spacing, Face Weight and Total Weight
5. ASTM D 2859 Flammability (Pill test)
6. ASTM F 1551 Water Permeability

F. Prior to Final Acceptance, the Turf Vendor shall submit to the owner three (3) copies of their maintenance manuals. These manuals will include all necessary instructions for the proper care and maintenance of the newly installed synthetic turf system.

1.02 SUBMITTALS

Submit the following with bid, as requested:

A. Turf Vendor’s current ASBA Certified Field Builder (synthetic) certificate.

B. Written certification that the synthetic turf will be installed by the Turf Vendor’s own in-house installation crew.

C. Three (3) copies of required 3rd party insurance policy, demonstrating that all the requirements outlined in Section 1.04 F Quality Assurance are met. Actual policy must be submitted.

Note: If these submittal items are requested and deemed to be insufficient, the Turf Vendor will not be approved.

Submit the following prior to the ordering of materials:

A. Provide a colored striping plan detailing lines, numbers and letters. Coordinate with Owner or Owner's Representative and Architect to get final approval of all designated colors, dimensions and logo/lettering designs.

B. Material Certificates and Samples: Provide three (3) copies for each material from material producer that will be used for this project. Each material certificate must be stamped and checked as approved by the Turf Vendor before submittal to the Architect.

C. Provide to the Architect materials samples of the following: Two (2) 12" x 12" samples of synthetic turf carpet and color yarn samples,two bagged samples each of rubber and sand infill material or two bagged samples of rubber infill material.

D. Submit two (2) 12" x 12" samples of shock pad with product data sheet, if Owner chooses this alternate.

E. Submittals: Prior to order of materials, the Turf Vendor shall submit a sample warranty, seam layout plan, striping plan and any details of construction that deviate from the plans and specifications.

F. Submit three (3) copies of the resume of proposed installation foreman. Installation crew must meet or exceed all requirements outlined in Section 1.04.

G. Three (3) copies of Field Builder's recommended maintenance cut sheets.

1.03 JOB CONDITIONS

A. All job conditions in Section 02200 apply.

1.04 QUALITY ASSURANCE

A. Provide a qualified installation foreman to coordinate and review the component parts of the artificial turf system. Submit a resume of experience for Architect's approval prior to starting work.

B. Artificial Turf:

1. Technicians employed by the Turf Vendor skilled in the installation of athletic-caliber infilled synthetic turf systems will undertake the placement of the turf. Special brushing equipment and techniques will be used in the installation.
2. The designated in-house installation crew shall have installed a minimum of thirty (30) high quality, stadium grade infilled synthetic turf systems of 65,000 square feet or greater in the past three years.
3. A notarized letter from the Turf Vendor that the installation crew and foreman are directly employed by the Turf Vendor must be submitted prior to the start of turf installation.

C. The Turf Vendor shall meet the following criteria:
1. Manufacturer:

a. The Turf Vendor must employ competent workmen skilled in this type of artificial turf installation. The designated Supervisory personnel on the project must be employed by, and certified, in writing, by the Turf Vendor as competent in the installation of this material, including gluing or sewing seams and proper installation of the infill mixture.

The Turf Vendor shall have a qualified job foreman on site to certify the installation and warranty compliance.

D. Warranty:

1. The warranty coverage shall not be prorated nor place limits on the amount of the field's usage.
2. The Field Builder shall submit its written company warranty: 8-year warranty which warrants the usability and playability of the artificial turf system for its intended uses. A 3rd party insured 8-year warranty from an A-Rated domestic insurance carrier is required in addition to the Field Builder's warranty. Letters of credit in lieu of an insurance policy are not acceptable.
3. The Field Builder's warranty must have the following characteristics:
    a. Provide full coverage for a minimum of eight (8) years from the date of Substantial Completion.
    b. Warrant materials and workmanship.
    c. Warrant that the materials installed meet or exceed the system specifications.
    d. Repair or replace such portions of the installed materials that are no longer serviceable to maintain a serviceable and playable surface.
    e. Be from a single source covering workmanship and all materials.
    f. Assure the availability of exact or substantially the same replacement materials for the artificial turf system installed for the full warranty period.
    g. Include general wear and damage caused from UV degradation. The warranty shall specifically exclude vandalism and acts of God beyond the control of the Turf Manufacturer or Field Builder.
    h. Cover defects in the installation and workmanship. Assure the installation was done in accordance with both the Field Builder's recommendations and any written directives of the Field Builder's on-site representative.
    i. Shall be limited to repair or replacement of the affected areas at the option of the Field Builder, and shall include all necessary materials, labor, transportation costs, etc. to complete said repairs.
    j. The Field Builder may be required, upon the request of the Owner, to provide a list of ten (10) clients for which they have completed after-the- sale warranty work.

k. All designs, game markings and layouts shall conform to all currently applicable National Federation State High School Association or NCAA rules and regulations, or league specific requirements, depending on what applies.

l. All components and Turf Vendor's installation methods shall be designed and manufactured for use on outdoor athletic fields. The materials as hereinafter specified, shall withstand full climatic exposure in the location of the field, be resistant to insect infestation, rot, fungus and mildew; it shall also withstand ultra-violet rays and extreme heat, it shall allow the free flow of water horizontally to perimeter areas and vertically to the gravel blanket and into the field drainage system below the surface.

m. The sewn primary seams of all system components shall provide a permanent, tight, secure and hazard-free athletic playing surface. All inlaid markings (game lines, logos, etc.) shall remain in place throughout the duration of the warranty period.

PART 2 – PRODUCTS

2.01 SYNTHETIC GRASS SYSTEM Synthetic Grass Basis of Design to be –

A. Field Turf "Fit Turf" (Base Bid); Sprinturf "Sport Pro" (Alternate).

The carpet shall be delivered in 15-foot wide rolls with the four (4") inch white, football 5- yard lines tufted into each roll, when applicable. The perimeter white line shall also be tufted into the individual sideline rolls, when applicable. The rolls shall be of sufficient length to go from sideline to sideline. Head seams, between the sidelines, will not be acceptable.

As applicable, provide game markings as follows: Hash marks, numbers, individual yard marks, and soccer, school logo and related markings shall be cut in and glued in accordance with Turf Vendor's recommendations (refer to drawings).

Provide a school logo as follows: Refer to drawings.

B. Seaming Materials:

Adhesives for bonding inlaid synthetic turf markings shall be two-component fast-set urethane adhesive obtained from a single manufacturer and be equivalent to Ultrabond Turf PU 2K as manufactured by Mapei Corporation, Deerfield Beach, FL (800) 992-6273, or approved equal as designated by the Turf Vendor.

Seaming Tape: Tape for securing inlays in the tufted synthetic turf shall be high quality tape made with a minimum roll width of 12 inches.

PART 3 – EXECUTION

3.01 SUBMITTALS

A. Prior to ordering materials, submit a 3rd party insured warranty policy, a sample warranty, seam layout of field, striping plan and all details of construction that deviate from the plans and specifications.

B. Pressure Treated Wood Turf Nailer: The synthetic turf perimeter fastening structure shall be installed before the drainage aggregate.

1. Install a pressure treated wood 2" x 4" nailer. Pressure treated wood nailer shall be set 1.5 inches below top of the curb by means of a Tapcon or ramset every 12 inches. See synthetic turf edge attachment detail.

C. Synthetic Turf and Infill Materials

1. After a final inspection and sign off of the finished stone base, the synthetic turf installation shall begin. The first roll shall begin with the longest perpendicular cross-field distance. No head seams shall be permitted in the inbound playing surface.

2. The rolls of turf shall be rolled out a minimum of four hours prior to starting seaming procedures and allowed to relax/expand.

a. All visible wrinkles shall be stretched out before seaming.

b. Seams shall be flat, tight and permanent with no separation or fraying.

c. Synthetic turf yarn fabric that is trapped or glued between seams shall be freed from the seams by hand or other approved method to an upright position prior to the commencement of brushing and top dressing procedures.

d. All synthetic turf seams shall be assembled as follows: The full width rolls shall be laid out across the field. Utilizing standard state of the art adhering or sewing procedures, each roll shall be attached to the next.

e. When all of the rolls of the playing surface have been installed, the sideline areas shall be installed perpendicular to the playing field. The yard lines, game markings, sidelines, etc. of all applicable sports shall be tufted into carpet by the manufacturer wherever possible.

D. Tufted and Inlaid Lines

1. Layout and descriptions of tufted, inlaid and/or painted lines shall be as indicated on final shop drawings.

2. Inlaid lines and field markings shall be cut in using seaming methods recommended by the Field Builder.

E. Synthetic Turf Perimeter Attachment:

1. After final trimming of the turf, the turf shall be screwed, nailed, stapled or glued to

the pressure treated wood nailer system as per the Field Builder's recommendations.

3.02 FIELD LAYOUT

A. Field layout shall be as shown on the record drawings. Typically, the final approved striping and seaming plan that was used to manufacture and install the field is acceptable. Any Owner-approved changes that took place during the installation must be marked in red and resubmitted.

3.03 CLOSEOUT

A. The Field Builder must verify that a qualified representative has inspected the installation and that the finished field surface conforms to the Field Builder's requirements.

B. The Field Builder shall provide a warranty to the Owner that covers defects in materials and workmanship of the turf for a period of 8 years from the date of Substantial Completion as described in 1.04 F. Submit three (3) copies of the warranty.

C. The company's 8-year warranty must also be supported by a 3rd party insured 8-year warranty from an A-rated domestic insurance carrier. The value of the policy shall be $10,000,000 for each insured warranty and $15,000,000 annual aggregate. Only true 3rd party policies will be accepted. Companies submitting policies that are actually letters of credit or not truly a 3rd party insurance policy will not be accepted. Submit three (3) copies of the actual insurance policy.

D. The Field Builder must submit three (3) copies of its standard maintenance manual to the owner.

E. Field Builder must train Owner's designated field personnel in proper grooming and care procedures. This includes training field personnel how to properly use grooming equipment as well as make minor repairs.

3.04 CLEAN UP

A. Field Builder shall provide the labor, supplies and equipment as necessary for final cleaning of surface and installed items.

B. All usable remnants of new material shall be neatly rolled up and turned over to the Owner at a place and area designated by the Owner.

C. During the contract and at intervals as directed by the Architect and as synthetic turf installation is completed, clear the site of all extraneous materials, rubbish, or debris and leave the site in a clean, safe, well draining, neat condition.

D. Surface, recesses, enclosures, etc. shall be cleaned as necessary to leave the work area in a clean, immaculate condition ready for immediate occupancy and use by the Owner.

3.05 G-MAX TESTING

A. Required at substantial completion, the Field Builder, as specified, hire an independent testing laboratory to perform a G-max test (ASTM 355, 1936 method) to verify that the shock attenuation properties of the field meet the requirements set forth in this specification. Submit three (3) copies of the G-max test to the Owner.

B. At the time of substantial completion, the average G-max rating must not exceed 125 at the time of install. The average G-max must not exceed 175 at any time during the life of the warranty. The Owner reserves the right to have the field tested for shock attenuation at its own cost at anytime it deems necessary. If at anytime the G-max ranges reach unacceptable levels, it is the responsibility of the Field Builder to bring the field back into the required ranges at no cost to the Owner. Include in the Base Bid 8 years of G-max testing performed once a year in the summer.

END OF SECTION 321214

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hot-mix asphalt paving.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving overlay.
4. Pavement-marking paint.
5. Cold milling of existing hot-mix asphalt pavement.
6. Precast concrete wheel stops.

B. Related Sections include the following:

1. Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.

1.3 DEFINITIONS

A. INDOTSS: Indiana Department of Transportation Standard Specifications.

1.4 SYSTEM DESCRIPTION

A. Provide hot-mix asphalt paving according to materials, workmanship, and other applicable requirements of standard specifications of state or of authorities having jurisdiction.

1. Standard Specification: As indicated.
2. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

B. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

C. Qualification Data: For firms and persons specified in the “Quality Assurance” article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses. Names and addresses of Architect and owners, and other information specified.

D. Material Test Reports: Indicate and interpret test results for compliance of materials with requirements indicated.

E. Material Certificates: For each paving material, signed by manufacturers.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.

1. Manufacturer shall be a paving-mix manufacturer registered with and approved by authorities having jurisdiction or INDOT.

B. Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

C. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination." Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

1. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
2. Review condition of subgrade and preparatory work performed by other trades.
3. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
4. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp or if the following conditions are not met:

1. Tack Coat: Minimum surface temperature of 60 deg F (15.5 deg C).
2. Asphalt Base Course: Minimum surface temperature of 40 deg F (4 deg C) and rising at time of placement.
3. Asphalt Surface Course: Minimum surface temperature of 60 deg F (15.5 deg C) at time of placement.

B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F (4 deg C) for oil-based materials, 50 deg F (10 deg C) for water-based materials, and not exceeding 95 deg F (35 deg C).

PART 2 – PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations. Furnace slag is not authorized.

B. Coarse Aggregate: ASTM D 692, sound; angular crushed stone or crushed gravel.

C. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, or combinations thereof.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

2.2 ASPHALT MATERIALS

A. Asphalt Cement: ASTM D 3381 for viscosity-graded.

B. Water: Potable.

2.3 AUXILIARY MATERIALS

A. Pavement Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FSTT-P-1952, with drying time of less than 45 minutes. Color as indicated.

B. Thermoplastic: INDOT 914.14

C. Glass Beads: AASHTO M247, Type 1.

D. Joint Sealant: ASTM D 6690 Type II, hot-applied, single-component, polymer-modified bituminous sealant.

E. Wheel Stops: Precast, air-entrained concrete, 2500-psi (17.2-MPa) minimum compressive strength, 6 inches (150 mm) high by 9 inches (225 mm) wide by 84 inches (2100 mm) long. Provide chamfered corners and drainage slots on underside and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 1/2-inch (12.5-mm) diameter, 30-inch (750-mm) minimum length.

2.4 MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:
1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: INDOT HMA 25.0 mm.
3. Surface Course: INDOT HMA 9.5 mm.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to support paving and imposed loads.

B. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.

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

3.2 COLD MILLING

A. Retain this Article if removing a course or layer from an existing hot-mix asphalt pavement. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill to a depth of 1-1/2 inches.
2. Mill to a uniform finished surface free of gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Retain first subparagraph below, if applicable.

7. Transport milled hot-mix asphalt to asphalt recycling facility.
8. Keep milled pavement surface free of loose material and dust.

3.3 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch (25 mm) in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 3 inches (75 mm) thick.

3.4 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.

B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at minimum temperature of 250 deg F (121 deg C).
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes, unless otherwise indicated.
5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches (150 mm).
3. Offset transverse joints, in successive courses, a minimum of 24 inches (600 mm).
4. Construct transverse joints as described in AI MS-22, "Construction of Hot Mix Asphalt Pavements."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.7 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction per INDOTSS.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Repair surfaces by loosening displaced material, filling with hot-mix asphalt, and rerolling to required elevations.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to AASHTO T 245, but not less than 94 percent nor greater than 100 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 INSTALLATION TOLERANCES

A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:
1. Base Course: Plus or minus 1/2 inch (13 mm).
2. Surface Course: Plus 1/8 inch (3 mm), no minus.

B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:
1. Base Course: 1/4 inch (6 mm).
2. Surface Course: 1/8 inch (3 mm).
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch (6 mm).

3.9 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner's Representative.

B. Allow pavement to age for 30 days before starting pavement marking unless directed otherwise by Owner's Representative when paint Manufacture's recommendations allow.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions and shapes indicated, with uniform, straight edges. Apply at Manufacture's recommended rates to provide a minimum wet film thickness of 15 mils.

3.10 WHEEL STOPS

A. Securely attach wheel stops into pavement at locations indicated with not less than two galvanized steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency acceptable to the Owner, Architect, and Engineer to perform tests and inspections.

B. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

C. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.

F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.12 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow excavated materials to accumulate on-site.

END OF SECTION 321216

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Poured-in-place concrete.

B. Concrete formwork.

C. Concrete reinforcement.

D. Sealing concrete.

1.2 RELATED WORK

A. Division 31 Section “Earth Moving” for aggregate subbase and base courses.

1.3 DESCRIPTION OF WORK

A. Provide concrete paving as shown and indicated, including curbs, slabs, walks, and pavement.

1.4 QUALITY ASSURANCE

A. Testing organization will take samples and perform tests accordance to Div. 1 and this Section. The Contractor shall employ the services of a reputable geotechnical engineering firm having experience in the project area to perform all testing. Contractor shall be responsible for payment for all associated costs of all required testing.

B. ACI-347 - Recommended Practice for Concrete Formwork.

C. ACI-318 - Reinforced Concrete; ACI-315 Manual of Standard Practice; CRSI-63; ASTM-A615.

D. ASTM-C94 - Ready-Mixed Concrete; ACI-304, 305 & 306; ASTM-C150; ASTM-C260; ASTM-C33.

E. Codes and Standards: Comply with Indiana Department of Transportation, Standard Specifications Section 501, unless more stringent requirements are herein indicated.

F. All cast-in-place concrete to be installed by a concrete contractor with at least five (5) years experience in similar concrete work.

1.5 SUBMITTALS

A. Furnish samples, manufacturer's product data, mix designs, test reports, and materials' certifications of all materials used in this section and as required by Division One specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Forms: Steel, wood or other suitable material of size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment until removal. Use straight forms, free of distortion and defects.

1. Use flexible spring steel forms or laminated boards to form radius bends as required. Coat forms with a nonstaining form release agent that will not discolor or deface surface of concrete.

B. Fine and Coarse Aggregate: ASTM C33. 3/4" max. size of coarse aggregate.

C. Synthetic Fiber: Fibrillated polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C 1116, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long, from Fibermesh Company, 4019 Industrial Drive, Chattanooga, Tennessee 37416, or approved equal.

D. Air Entraining - ASTM C260; equal to W.R. Meadows Air Entraining Agent.

E. Expansion Joint Materials: 1/2" x respective thickness resilient, closed cell polypropylene foam material; equal to W.R. Meadows Sealtight Rescore Expansion Joint Filler.

F. Sealant: One part self-leveling polyurethane sealant like Sonneborn's "Sonolastic SL1", ASTM C-920, Type S, Grade P, Class 25, Limestone color.

G. Liquid-Membrane Forming Curing and Sealing Compound:

1. Products: Subject to compliance with requirements, provide one of the following:
Silencure SRT by ChemMasters
Silencure by ChemMasters

H. Epoxy Bonding Adhesive: Unitex Pro-Poxy 284.

I. Welded Wire Fabric: ASTM A 185, Welded Steel Wire Fabric.

J. Reinforcing Bars: ASTM A 615, grade 60, deformed.

2.2 CONCRETE MIX, DESIGN AND TESTING

A. Design mix to produce standard weight concrete consisting of Portland cement, aggregate, water reducing, or high range water reducing admixture (superplasticize), air entrancing admixture and water to produce the following properties:

1. Compressive Strength: 4000 psi, minimum at 28 days.
2. Slump Range: 8" for concrete containing high range water reducing (superplasticizer); 3" for other concrete.
3. Air Content: Type 1A (5-7% air), Portland Type, ASTM C150.
4. Mix concrete in accordance with ASTM C94.

B. Fiber Reinforcement:

1. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer’s recommended rate, but not less than 1.5 lb/cu. Yd. (0.9 kg/cu. M).

PART 3 - EXECUTION

3.1 WORKMANSHIP AND INSTALLATION

A. Inspect prepared subgrade surface to check for unstable areas and need for additional compaction. Do not begin concrete work until such conditions have been corrected and are ready to proceed.

3.2 AGGREGATE BASE

A. Place aggregate base where required to conform with Section 31 20 00 Earth Moving.

B. Remove loose material from compacted subgrade or aggregate base surface immediately before placing concrete.

3.3 FORM CONSTRUCTION

A. Set forms to required grades and lines, rigidly braced and secured. Install sufficient quantity of forms to allow continuous progress of work and so that forms can remain in place at least 24 hours after concrete placement.

B. Check completed formwork for grade and alignment to following tolerances:

1. Top of forms not more than 1/8" in 10'.
2. Vertical face on longitudinal axis, not more than 1/4" in 10'.

C. Clean forms after each use, and coat with form release agent as often as required to ensure separation from concrete without damage.

3.4 REINFORCEMENT

A. Place reinforcing supported and secured against displacement. Before placing concrete, ensure reinforcing is clean, free of loose scale, dirt or other foreign coating which would reduce bond to concrete.

3.5 CONCRETE PLACEMENT

A. Do not place concrete until forms have been checked for line and grade. Moisten subgrade or aggregate base if required to provide a uniform damped condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

B. Place concrete using methods which prevent segregation of mix. Consolidate concrete along face of forms and adjacent to traverse joints with internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocation of reinforcing, dowels, and joint devices.

C. Deposit and spread concrete in a continuous operation between transverse joints, as far as possible. If interrupted for more than 1/2 hour, place a construction joint.

3.6 JOINTS

A. General: Construct expansion, weakened plane (contraction), and construction joints true to line with face perpendicular to surface of concrete. Construct transverse joints at right angles to the centerline, unless otherwise indicated.

1. When joining existing structures, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Weakened Plane (Contraction) Joints: Provide weakened plane (contraction) joints, sectioning concrete into areas as shown on drawings. Construct weakened plane joints for a depth equal to at least 1/4 concrete thickness, as follows:

1. Tooled Joints: Form weakened plane joints in fresh concrete by grooving top portion with a recommended cutting tool and finishing edges with a jointer.
2. Sawed Joints: Form weakened plane joints using powered saws equipped with shatterproof abrasive or diamond rimmed blades. Cut joints into hardened concrete as soon as surface will not be torn, abraded, or otherwise damaged by cutting action. Sawed joints shall receive rounded edge similar to tooled/grooved joints.
3. Inserts: Use embedded strips of metal or sealed wood to form weakened plane joints. Set strips into plastic concrete and carefully remove strips after concrete has hardened.

C. Construction Joints: Place construction joints where placement operations are stopped for a period of more than 1/2 hour, except where such pours terminate at expansion joints.

1. Construct joints as shown or, if not shown, use standard metal keyway section forms.
2. Where load transfer slip dowel devices are used, install so that one end of each dowel bar is free to move.

D. Expansion Joints: Provide expansion joints of pre-molded joint filler at a maximum of 20' o.c., unless otherwise indicated, and at all curb radii and locations abutting concrete curbs, catch basins, manholes, inlets, structures, walks, or other fixed objects.

1. Extend joint filler full width and depth of joint, and not less than 1/2" or more than 1" below finished surface.
2. Furnish joint fillers in one piece lengths for full width being placed, wherever possible. Where more than one length is required, lace or clip joint filler sections together.
3. Protect top edge of joint filler during concrete placement with a metal cap or other temporary material. Remove protection after concrete has been placed on both sides of joint.
4. Install Fillers and Sealants: Comply with the requirements of this Section Paragraph 02.01 E & F.

3.7 CONCRETE FINISHING

A. After striking off and consolidating concrete, smooth surface by screeding and floating. Use hand method only where mechanical floating is not possible. Adjust floating to compact surface and produce uniform texture.

1. After floating, test surface for trueness with a 10' straightedge. Acceptable surface tolerance/flatness shall be 1/8” in 10’ with straightedge placed in any direction. Distribute concrete as required to remove surface irregularities, and refloat repaired areas to provide a continuous smooth finish.
2. Work edges of slabs and formed joints with an edging took, and round to 1/2" radius, unless otherwise indicated. Eliminate tool marks on concrete surface.

3. After completion of floating and troweling when excess moisture or surface sheen has disappeared, complete surface finishing as indicated on plans or, if not shown, finish as outlined in "Final Finish".

B. Final Finish: After screeding and floating, an initial troweling shall be given the surface when it has hardened enough so that water and fine material are not worked to the top.

1. Walks and Steps finish; medium broom finish, perpendicular to line of traffic. Repeat operation if required to provide texture acceptable to Architect/Engineer.
2. On Entrance Drive surfaces, provide a coarse, nonslip finish by scoring surface with a stiff bristled broom, perpendicular to line of traffic.
3. Exposed concrete light bases: Remove all form marks and rub to a smooth finish within 24 hours.
4. Do not remove forms for 24 hours after concrete has been placed. After form removal, clean ends of joints and point up any minor honeycombed areas. Remove and replace unacceptable areas or sections with defects, as directed by Architect/Engineer and Owner's Representative.

C. Exposed Concrete Light Bases: Remove all form makes and rub to a smooth finish.

3.8 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. In hot, dry, and windy weather protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply, according to manufacturer's instructions after screeding and bull floating, but before power floating and troweling.

B. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.

C. Curing Methods: Cure concrete by curing compound, by moist curing, by moisture-retaining cover curing, or by combining these methods, as specified.

D. Provide moisture curing by the following methods:

1. Keep concrete surface continuously wet by covered with water.
2. Use continuous water-fog spray.
3. Cover concrete surface with specified absorptive cover, thoroughly saturate cover with water, and keep continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with a 4-inch lap over adjacent absorptive covers.

E. Provide moisture-retaining cover curing as follows:

1. Cover concrete surface with moisture-retaining over for curing concrete, placed in widest practicable width with sides and ends lapped at least 3 inches and sealed by waterproofed tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

F. Apply curing compound on exterior slabs, walks, and steps as follows:

1. Apply curing compound to concrete as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation

by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

2. Use membrane curing compounds that will not affect surfaces to be covered with finish materials applied directly to concrete.

3.9 REPAIRS AND PROTECTIONS

A. Repair or replace broken or defective concrete, as directed by Architect/ Engineer.

B. Drill test cores where directed by Architect/Engineer, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to pavement with epoxy resin grout.

C. Protect concrete from damage and graffiti until acceptance of work. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

D. Sweep concrete pavement and wash free of stains, discolorations, dirt and other foreign material just prior to final inspection.

END OF SECTION 321313

PART 1- GENERAL

1.01 SUMMARY

A. The contract work to be performed under this section consists of furnishing all required labor, materials, equipment, implements, parts and supplies necessary for, the surfacing in accordance with these specifications and indicated on the drawings.

1. Spurtan BS - Polyurethane bound running track surface with structural spray finish or approved equal.
2. Conipur SP Permeable Structural Spray Coating System is an approved product.

1.02 CODES AND STANDARDS

A. Codes and standards follow the current guidelines set forth by the International Associations of Athletics Federation (IAAF), the National Collegiate Athletic Association (NCAA) or the National Federation of State High School Associations (NFHS).

1.03 SUBMITTALS AND SUBSTITUTIONS

A. Request for deviations or substitutions from the specifications must be made in writing seven days prior to the bid date. Complete product data including specifications, application rates, mixing instructions and a sample shall be sent with the request to the district and/or its agent for an evaluation. Alternatives will be allowed only by addendum.

1. Submit manufacturer's product data sheets including installation guidelines and maintenance instructions.
2. Submit Material Safety Data Sheets (MSDS) for all individual components of the system to be installed.
3. Submit evidence that the synthetic surfacing contractor is a member of the American Sports Builders Association (ASBA).
4. Submit product information that meets track surface manufacturer's approval regarding procedures and products for repair of any existing cracking in asphalt.

1.04 QUALITY ASSURANCE

A. The track surface will be applied by an installer authorized by manufacturer. The contractor shall have a current contractor's license, as well as a current sales tax and use tax number when applicable.

B. Successful contractor will provide proof of insurance as well as performance and payment

bonds if required.

C. All polyurethanes used must be manufactured by an ISO 9001Certified company.

1.05 SITE CONDITIONS

A. Weather: Surfacing shall not be done when the threat of freezing exists for the following 24 hours, rain is imminent or gusting winds are occurring.

B. Site: While surfacing and striping are being done, sprinkler systems must be curtailed, shut off, or controlled so that no water falls on the track or event area surfaces. Other trades and school district personnel must stay off the wet or curing surfaces.

C. Do not apply rubberized topping when base surface temperature is less than 40° F.

D. Provide temporary barriers as required to prevent public entry to construction area and to protect adjacent properties from damage during construction operation.

1.06 WARRANTY

A. Provide manufacturers standard 5 year warranty

PART 2- PRODUCTS

2.01 MANUFACTURERS

A. Advanced Polymer Technology 109
Conica Lane; PO Box 160
Harmony, PA 16037
724-452-1330
B. Beynon Sports BSS 100.

2.02 MATERIALS

A. Spurtan BS Running Track Surface: Polyurethane bound permeable SBR with structural spray finish. The basemat is paved at an average finish depth of 10 mm. Two coats of a one component Qualipur structural spray mixed at a rate of 60% liquid to 40% EPDM spray rubber are then applied. The final depth for the Spurtan BS track system is a minimum of 13 mm.

Materials include:

1. Qualipur Polyurethane primer
2. SBR or as specified
3. Qualipur Polyurethane binder
4. 0.5 - 1.5 EPDM Spray Rubber
5. One-Component Qualipur Structural Spray.

PART 3- EXECUTION

3.01 EXAMINATION

A. Crack Repair: Repair any existing cracks in asphalt track pavement prior to installation of track surface system.

B.

C. Verify asphalt concrete paving for dimensional accuracy, strength, and surface preparation. Notify owner of any deficiencies. Recommended compaction of asphalt and sub base is 95%.

D. It is the responsibility of the paving contractor to water flood the surface with the use of a water truck. If after 30 minutes on a 70° F day, “bird bathes” are evident in a depth more than 1/8” the paving contractor, track surfacing contractor and the owner’s representative will determine the best method of correction.

E. Entire surface shall be clean and free of all dirt, oil, grease or any other foreign matter. It is the responsibility of the general contractor to thoroughly clean and/or pressure wash all areas of the new and/or existing asphalt or concrete base as necessary to ensure adhesion of the track surface.

F. Minimum curing time for base prior to beginning of surfacing is 14 days for new asphalt paving and 28 days for new concrete. No concrete curing compounds are allowed.

G. Beginning installation stipulates track installer “accepts” existing conditions. Adhesion to the existing asphalt is the surfacing contractor’s responsibility.

3.02 PRODUCT AND MATERIAL DESCRIPTION

A. The Spurtan BS synthetic surfacing system shall be a 13 mm thick, permeable paved mat with structural spray. The base layer is a paved in place rubber granule and a Qualipur polyurethane binder basemat.
Two coats of a mixture of colored Qualipur polyurethane and Melos EPDM 0.5 - 1.5 mm rubber (or approved equivalent) are then structurally sprayed onto the base to form a textured finish.

B. Rubber (SBR): The basemat rubber shall be specifically graded Styrene Butadiene Rubber (SBR). Final gradation is to be 1.0 - 3.0 mm granulated SBR. SBR is to be dried to no less than 2.5% moisture and sealed in bags.

C. Basemat Binder: The basemat shall be bound by a moisture-cured, Qualipur polyurethane, compatible with the basemat rubber. No asphaltic emulsions or epoxies are allowed in the basemat. Installation of the basemat shall take place with a specially designed track-paving machine to an average finish depth of 10 mm. No sprayed basemat systems will be allowed.

D. One-Component Structural Spray: The basemat shall be coated by a one component, solvent based, Qualipur polyurethane resin based, structural spray mixed with Melos 0.5 - 1.5 mm rubber (or approved equivalent).

3.03 APPLICATIONS PROCEDURES

A. The entire asphalt or concrete track surface shall be clean and free of dirt, oil, grease, or any other matter upon arrival of the installation team. Any dirt, construction debris etc. shall be pressure washed off the base by the general contractor prior to the arrival of the track installation crew.

B. Prime entire surface area with a compatible Qualipur polyurethane primer. Qualipur 1020 for asphalt and Qualipur 1220 for concrete or over an existing surface at an approximate rate of .16 kg/m² (.30 lbs/yd²).

C. The basemat is to be applied at an approximate total rate of 10.17 kgs/m² (18.75 lbs/yd²). 8.13 kgs/m² (15.00 lbs/yd²) of SBR rubber combined with 2.03 kgs/m² (3.75 lbs/yd²) of a Qualipur polyurethane binder is needed to achieve an average finished depth of 10 mm. The installation of the basemat is to take place using a paving machine that is specifically designed for this type of application.

D. The one component Qualipur structural spray should be mixed with Melos EPDM 0.5 – 1.5 mm rubber (or approved equivalent) at a rate of 60% structural spray to 40% rubber. The mixture should be sprayed in two layers at .97 kgs/m² (1.80 lbs/yd²), each coat for a total consumption rate of approximately 1.95 kgs/m² (3.60 lbs/yd²) minimum.

3.04 STRIPING AND MONUMENTATION

A. The contractor shall consult with the owner prior to the start of their calculations for determination of the finish line location, events to be run, location of lane numbers and additional paint markings

B. All line marking paint is to be approved by the synthetic surfacing manufacturer. Only an experienced track-striping specialist shall perform the line striping.

END OF SECTION 322569

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sodding
2. Seeding.

B. Related Sections:

1. Division 31 Section "Earth Moving" for excavation, filling and backfilling, and rough grading.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

C. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill immediately beneath planting soil.

E. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Certification of Sod: Certification of each seed mixture for turfgrass sod, identifying source, including name and telephone number of supplier.

C. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for turfgrass sod, identifying source, including name and telephone number of supplier.

D. Qualification Data: For qualified landscape Installer.

E. Product Certificates: For soil amendments and fertilizers, from manufacturer.

F. Material Test Reports: For existing surface soil and imported topsoil.

G. Planting Schedule: Indicating anticipated planting dates for each type of planting.

H. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of lawns and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful lawn establishment.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
2. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

1. Report suitability of topsoil for lawn growth. State-recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.

D. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in TPI's "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in its

"Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

1.7 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

1. Spring Planting: April 15 to May 15, inclusive.
2. Fall Planting: August 15 to October 15, inclusive.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.8 PERFORMANCE REQUIREMENTS

A. All turf areas disturbed as part of this project shall receive sod or seed as indicated on the drawings.

1.9 MAINTENANCE SERVICE

A. Initial Lawn Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:

1. Seeded Lawns: 60 days from date of planting completion.

a. When initial maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.

2. Sodded Lawns: 30 days from date of planting completion.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species: Seed of grass species as follows, with not less than 85 percent germination, not less than 98 percent pure seed, and not more than 0.5 percent weed seed:

1. Seed Species: Turf type tall fescue and Kentucky bluegrass blend as follows or approved equal:

a. Grade II Tall Fescue – 30%

b. Regiment II Tall Fescue – 30%
c. Blade Runner Tall Fescue – 30%
d. Wildhorse Kentucky Bluegrass – 10%

2.2 TURFGRASS SOD

A. Turfgrass Sod: ASPA certified nursery-grown grade, complying with TPI's "Specifications for Turfgrass Sod Materials" in its "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture; strongly rooted; free of stones, burned or bare spots; containing no more than ten (10) weeds per 100 sq. ft.; and capable of vigorous growth and development when planted.

1. Minimum Age: 18 months.

B. Turfgrass Species: State-certified sod of grass species as follows, with not less than 90 percent germination, not less than 97 percent pure seed, and not more than 0.5 percent weed seed:

1. Turfgrass Blend: Kentucky bluegrass turf type tall fescue mix; 10 percent bluegrass and 90 percent turf type tall fescue consisting of a minimum of three varieties each:

C. Harvesting Sod: Machine-cut sod not less than one (1) sq. yd. in area with a minimum of 3/4 inch and a maximum of 1-1/4 inch topsoil base. Minimum width shall be eighteen (18) inches. Broken pads or pads with uneven ends shall not be acceptable

2.3 TOPSOIL

A. Topsoil: ASTM D 5268, pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth.

1. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs or marshes.

2.4 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural limestone containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.

2.5 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5

to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.6 PLANTING ACCESSORIES

A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

2.7 FERTILIZER

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.8 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

2.9 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable or, straw, or coconut-fiber matrix sewn between two natural fiber nets. Include manufacturer's recommended steel wire staples, 6 inches long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

2.10 PLANTING SOIL MIX

A. Planting Soil Mix: Topsoil mixed with the following soil amendments and fertilizers in the following quantities:

1. Ratio of Loose Compost to Topsoil by Volume: 1:4.
2. Weight of Commercial Fertilizer per 1000 Sq. Ft.: as required by soils report.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive lawns and grass for compliance with requirements and other conditions affecting performance.

B. Proof roll topsoil as required to ensure settling is minimized while ensuring optimum growing conditions for the plant materials.

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

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 LAWN PREPARATION

A. Limit lawn subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches. Remove stones larger than 3/4 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply fertilizer directly to subgrade before loosening.
2. Thoroughly blend planting soil mix off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil mix.

a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
b. Mix lime with dry soil before mixing fertilizer.

3. Spread planting soil mix to a depth of 4 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

a. Spread approximately 1/2 the thickness of planting soil mix over loosened subgrade. Mix thoroughly into top of subgrade. Spread remainder of planting soil mix.
b. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Unchanged Subgrades: If lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:

1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil. Till soil to a homogeneous mixture of fine texture.

    a. Apply fertilizer directly to surface soil before loosening.

3. Remove stones larger than 3/4 inch in any dimension and sticks, roots, trash, and other extraneous matter.
4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, restore areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Lawn Preparation" Article.

B. For erosion-control mats, install planting mix in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.

C. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

D. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 TURF SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.
2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 3 to 4 lb/1000 sq. ft.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with slopes not exceeding 1:4 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment..

3.6 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.
3. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

3.7 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across angle of slopes exceeding 1:3.
2. Place top elevation of sod 1/2 inch below adjacent pavement.
3. Place sod in a single strip adjacent to all pavement.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.8 LAWN RENOVATION

A. Renovate existing lawn.

B. Renovate existing lawn damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.

1. Reestablish lawn where settlement or washouts occur or where minor regrading is required.
2. Provide new topsoil as required.

C. Remove sod and vegetation from diseased or unsatisfactory lawn areas; do not bury in soil.

D. Remove topsoil containing foreign materials resulting from Contractor's operations, including oil drippings, fuel spills, stone, gravel, and other construction materials, and replace with new topsoil.

E. Mow, dethatch, core aerate, and rake existing lawn.

F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.

I. Apply soil amendments and initial fertilizers required for establishing new lawns and mix thoroughly into top 4 inches of existing soil. Provide new planting soil to fill low spots and meet finish grades.

J. Apply seed and protect with straw mulch sod as required for new lawns.

K. Water newly planted areas and keep moist until new lawn is established.

3.9 LAWN MAINTENANCE

A. Maintain and establish lawn by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn. Provide materials and installation the same as those used in the original installation.

1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
2. Repair eroded areas by filling with topsoil, regrading, and replanting.

B. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawn uniformly moist to a depth of 4 inches.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water lawn with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
3. Do not use open-ended or nozzled hoses.

C. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow grass to a height of 2 to 3 inches.

D. Lawn Post Fertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. to lawn area.

E. Maintenance shall begin immediately after each portion of lawn is seeded or sodded. Maintenance prior to inspection shall be the Contractor's responsibility. A five (5) day notice shall be given to the Owner and Engineer requesting an inspection/approval date. At the time of inspection, the Owner and Engineer reserve the right to postpone final acceptance of rejection can be determined. After acceptance by Owner, all maintenance shall be taken over by Owner.

3.10 SATISFACTORY LAWNS

A. Lawn installations shall meet the following criteria as determined by Engineer:

1. Satisfactory Seeded Lawn: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
2. Satisfactory Sodded Lawn: At end of maintenance period, a healthy, well-rooted, even-colored, viable lawn has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

3.11 CLEANUP AND PROTECTION

A. Promptly remove soil and debris, created by lawn work, from paved areas and gravel running path. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary 36-inch high fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after lawn is established.

C. Remove nondegradable erosion-control measures after grass establishment period.

D. Allow only vehicles and equipment required to perform and maintain work of this Section onto completed lawn areas.

END OF SECTION 329200

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Indiana Department of Environmental Management (IDEM) – Article 327 IAC 8.

C. Great Lakes Upper Mississippi River Board of State Public Health & Environmental Managers (GLUMRB) – Recommended Standards for Water Works.

D. National Fire Protection Association (NFPA) Guidelines.

E. Linton Municipal Utilities: Linton Water Department standards.

1.2 SUMMARY

A. This Section includes water-distribution piping and related components from outside the building for domestic and fire service lines.

B. Related Sections include the following:

1. Division 31 Section “Earth Moving” for trench work and accessories.
2. Division 31 Section “Excavation and Support Protection” for excavation support and protection.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, including, but not limited to the following:

1. Pipe and Fittings.
2. Valves.
3. Locate Wire.

B. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, specialty locations, and elevations.

C. Shop Drawings: For vaults, including castings.

D. Field quality-control, pressure testing, and disinfection test reports.

E. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

F. Qualifications for Contractors Performing installation of Line Stops in active water mains: Submit data complying with requirements specified in the "Quality Assurance Article".

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

D. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

E. NSF Compliance:

1. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping 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.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution 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 Engineer and Owner no fewer than seven days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Engineer's and Owner's written permission.

1.7 COORDINATION

A. Coordinate with Water Working Foreman Ross Gentry at the Linton Water Department at (812) 847-4971 and with Linton-Stockton MS-HS Director of Maintenance Tom Andis at (812) 798-0229. Contractor responsible for all fees associated with the designed improvements.

PART 2 - PRODUCTS

2.1 GENERAL

A. All products shall comply with these specifications and/or applicable codes, whichever is more stringent, and shall be as indicated on the drawings

2.2 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper.

1. Copper, Pressure-Seal Fittings:

a. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
b. NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

2.3 PE PIPE AND FITTINGS

A. PE, Blue Polyethylene, AWWA C901 PE4710, ASTM D2737, CTS SDR No. 9, PC250, NSF 61.

1. Compression type pack joint with grooved clamp or quick joint with stainless steel gripper ring for PE(CTS) pipe.

2.4 DUCTILE-IRON PIPE AND FITTINGS

A. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated. Pressure class shall be 350. The pipe shall be lined with an approved thin Portland cement spun lining and a bituminous seal in accordance with the latest revision of ANSI/AWWA C104/A21.

1. Mechanical Joint, Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern. Fittings shall be cement-lined and coated, same as pipe.
2. Gaskets: AWWA C111, rubber.

2.5 PVC PIPE AND FITTINGS

A. PVC, AWWA Pipe: AWWA C900 (DR-14), Class 200, with bell end with gasket, and with spigot end.

1. Comply with UL 1285 for fire-service mains if indicated.
2. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

a. Gaskets: AWWA C111, rubber.

3. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. PVC, SDR 21: ASTM D 2241.

1. PVC Fabricated Fittings: Class 200, push-on type with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.

C. PVC, SDR 17: ASTM D 2241, 250 PSI, IPS Pressure Pipe

1. Mechanical-Joint, Ductile-iron Fittings: AWWA C153, ductile-iron compact pattern.

a. Glands, Gaskets, and Bolts: AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

2.6 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.7 CORPORATION VALVES AND CURB VALVES

A. Manufacturers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ford Meter Box Company, Inc.
b. McDonald
c. Mueller Co.; Water Products Div.
d. Or approved equivalent made in the U.S.A.

B. Service-Saddle Assemblies: Comply with AWWA C800.

1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.

C. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

D. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches in diameter.

1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

2.8 TRUST RESTRAINT

A. Restrained Joints: Mechanical Joint Restraints, EBAA Iron, Inc. MEGALUG or approved equal.

2.9 POLYETHYLENE ENCASEMENT

A. Polyethylene encasement sleeves for ductile iron pipe shall be 8-mil high-density cross-laminated (HDCL), polyethylene encasement material furnished and installed in accordance with AWWA C-105, ANSI 21.5 to provide the pipe with a protective enclosure.

2.10 LOCATOR WIRE

A. #12 insulated high strength copper clad steel (HS-CCS) wire.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Underground Fire and Domestic Water Service Piping shall be the following:

1. As indicated or approved alternative.

3.3 PIPING INSTALLATION

A. Water-Main Connection: Coordinate with the Linton Water Department.

B. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

1. Install polyethylene encasement material inclusive of valves and fittings. The material shall be furnished and installed in accordance with ANSI/AWWA C-105/A21.5, using plastic tie straps, circumferential wraps, or adhesive tape proving the pipe with a secure protective enclosure.

C. Bury piping with depth of cover over top at least 54 inches.

D. Install copper tubing and fittings according to CDA's "Copper Tube Handbook."

E. Extend water-service piping and connect to water-supply source and building-water-piping systems in locations and pipe sizes indicated.

F. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

G. Extend water-service piping and connect to water-supply source and building-water-piping systems to 5-feet outside of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping 5-feet outside building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Coordinate building-water-piping systems to ensure a complete installation.

H. Install underground piping with restrained joints per manufacture's requirements.

3.4 JOINT CONSTRUCTION

A. Make pipe joints according to the following:

1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
2. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
3. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
4. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure. Refer to Division 2 Section "Piped Utilities - Basic Materials and Methods" for joining piping of dissimilar metals.

3.5 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Set-screw mechanical retainer glands.
2. Bolted flanged joints.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
3. Fire-Service-Main Piping: According to NFPA 24.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.6 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.

C. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

D. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect water-distribution piping to interior domestic water piping.

3.8 FIELD QUALITY CONTROL

A. Piping Tests: Contractor to conduct piping tests under the observation of the Linton Water Department and the Linton-Stockton MS-HS Director of Maintenance before joints are covered and all joint restraints are in place. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.

1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities in accordance with NFPA requirements.

3.9 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving."

3.10 CLEANING

A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:

a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 331000

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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 gravity-flow, nonpressure, drainage piping and force-main, pressure rated piping for storm drainage from 5-feet outside the building as well as roof drainage piping including downspout boots at the face of building.

B. Related Sections include the following:

1. Division 31 Section “Earth Moving” for trench work and accessories.
2. Division 31 Section “Excavation and Support Protection” for excavation support and protection.
3. Division 31 Section “Excavation and Fill” for utility trench work.

1.3 DEFINITIONS

A. HDPE: Polyethylene plastic.

B. PVC: Polyvinyl chloride plastic.

C. RCP: Reinforced concrete pipe.

D. DIP: Ductile iron pipe.

1.4 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: Pipe joints shall be watertight.

1.5 SUBMITTALS

A. Product Data for each type of manufactures material and product indicated.

B. Shop Drawings for the following:

1. Manholes: Include plans, elevations, sections, details, and frames and covers.
2. Catch Basins and Stormwater Inlets: Include plans, elevations, sections, details, and frames,

covers, and grates.
3. Pre-cast or cast in place concrete storm structures.
4. Each underground detention facility: Include plan, elevation, sections, and details for complete installation.
5. Impact basins: Include plan, elevations, sections, details, and steel reinforcing. Shop drawing shall be prepared and sealed by a license in the state of Indiana.

C. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and special relationship between manholes, piping, and proximate structures.

D. Field quality-control test reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

1.7 PROJECT 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 Engineer and Owner’s Representative no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect's and Owner Representative’s written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.3 HDPE PIPE AND FITTINGS

A. Corrugated HDPE Drainage Pipe and Fittings: AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: HDPE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.

2.4 PVC PIPE AND FITTINGS

A. PVC Water-Service Pipe and Fittings: ASTM D 1785, Schedule 40 pipe, with plain ends for solvent-cemented joints with ASTM D 2466, Schedule 40, socket-type fittings.

B. PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

C. PVC Sewer Pipe and Fittings, NPS 18 and Larger: ASTM F 679, T-1 wall thickness, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

D. PVC Corrugated Sewer Pipe with a smooth interior and Fittings: ASTM F 949-93a, with bell-and-spigot ends and gasketed joints with ASTM F 477, elastomeric seals.

2.5 PVC PRESSURE PIPE AND FITTINGS

A. PVC Sewer Pipe and Fittings: ASTM D 2241, SDR-21 (PR200), for gasketed joints.

1. PVC Pressure Fittings: AWWA C907, for gasketed joist.
2. Gaskets for PVC Piping: ASTM F477, elastomeric seals.
3. Ductile-Iron, Compact Fittings: AWWA C153, for push-on joints.
4. Gaskets for Ductile-Iron Fittings: AWWA C111, rubber.

2.6 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, with bell-and-spigot or groove and tongue ends and gasketed joints with ASTM C 443, rubber gaskets.

1. Class III, Wall B.

2.7 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Nonpressure-Type, Rigid Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Available Manufacturers:
   a. ANACO.
   b. Cascade Omega Series.
   c. Fernco.

2.8 LOCATOR WIRE

A. #12 insulated high strength copper clad steel (HS-CCS) wire.

2.9 CLEANOUTS

A. Cast-Iron Cleanouts: ASME A112.36.2M; with round-flanged, cast-iron housing; and cast-iron cover as indicated. Include cast-iron ferrule and countersunk, brass cleanout plug.

B. PVC Cleanouts: ASTM D 3034, PVC cleanout threaded plug and threaded pipe hub with round-flanged, cast-iron housing; and cast-iron cover as indicated.

2.10 MANHOLES AND CATCH BASINS

A. Standard Precast Concrete Manholes and Catch Basins: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Diameter: 48 inches minimum, unless otherwise indicated.
2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
4. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.

5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
7. Steps: Individual FRP steps, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 48-inches.
8. Pipe Connectors: Fill void between pipe and opening in concrete barrel with Class A grout. Do not use brick or other material as a filler between pipe and barrel. Grout flush inside and exterior of barrel at connection to smooth appearance/surface with inside of barrel and convex to outside of barrel. Cover interior and exterior grouted area with trowel grade bituminous water proofing material 12-inches beyond opening in barrel around pipe.
9. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
10. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch- minimum width flange and 26-inch diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
    a. Material: ASTM A563, Grade 80-55-06 ductile iron, or ASTM A 48, Class 35B gray iron, unless otherwise indicated.
11. Catchbasin Frames and Grates: As indicated on Storm Structure Data Table Include indented design with lettering cast into cover, using wording equivalent to "DUMP NO WASTE – DRAINS TO CREEK."
    a. Material: ASTM A563, Grade 80-55-06 ductile iron, or ASTM A 48, Class 35B gray iron, unless otherwise indicated.

2.11 CONCRETE

A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (420 MPa), deformed steel.

C. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (420 MPa), deformed steel.

2.12 STORMWATER INLETS

A. Frames and Grates: Heavy-duty frames and grates according to utility standards, as indicated on the Storm Structure Data Table.

B. Solid covers shall have the words “STORM SEWER” cast in surface. All inlet and catchbasin frames shall be imprinted with the words: “DUMP NO WASTE – DRAINS TO CREEK.”

2.13 DOWNSPOUT BOOTS

A. Downspout Boots: Cast iron hub, same shape as downspout (i.e. square, rectangular), size to accept downspout size, Neenah Type R-4929-05 offset or approved equal. Boot shall be shop primed by manufacturer and painted, color as selected by architect.

2.14 PIPE OUTLETS

A. Riprap Basins: Broken, irregular size and shape, graded stone.

1. INDOTSS uniform riprap.

B. Pipe End Sections: Dimension and type indicated.

2.15 STORMWATER DETENTION SYSTEM

A. Piped System: As indicated by Contech or approved equal.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPING APPLICATIONS

A. Gravity-Flow, Nonpressure Sewer Piping: As indicated on drawings.

3.3 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific

installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.

F. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
2. Install HDPE corrugated sewer piping according to CPPA's "Recommended Installation Practices for Corrugated Polyethylene Pipe and Fittings."
3. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
4. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
5. Install precast reinforced-concrete box culverts sections according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.4 PIPE JOINT CONSTRUCTION

A. Basic pipe joint construction per piping manufacturer's written instructions.

B. Join force-main, pressure piping according to the following:

1. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.
2. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
3. Join PVC pressure piping according AWWA M23 for gasketed joints.
4. Join PVC water-service piping according ASTM D 2855.
5. Join dissimilar pipe materials with pressure-type couplings.

C. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join corrugated HDPE piping according to CPPA 100 and the following:

a. Use silttight couplings for Type 2, silttight joints.

2. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
3. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
4. Join dissimilar pipe materials with nonpressure-type rigid couplings.

3.5 DRAIN INSTALLATION

A. Install type of drains in locations indicated.

1. Use light-duty, top-loading classification drains in earth or unpaved foot-traffic areas.
2. Use medium-duty, top-loading classification drains in paved foot-traffic areas.
3. Use heavy-duty, top-loading classification drains in vehicle-traffic service areas.
4. Use extra-heavy-duty, top-loading classification drains in roads areas.

B. Embed drains in 4-inch minimum depth of concrete around bottom and sides.

C. Fasten grates to drains if indicated.

D. Set drain frames and covers with tops flush with pavement surface.

3.6 CLEANOUT INSTALLATION

A. Cleanouts for Sanitary Sewer Service Laterals:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction or as otherwise indicated. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete block, 18 by 18 by 12 inches in depth. Set tops flush with grade. Cast-iron pipe may also be used for cleanouts in nonvehicular-traffic areas.
3. In nonvehicular-traffic areas, use PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete block, 18 by 18 by 12 inches in depth. Set tops 1 inch above grade.

3.7 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections according to ASTM C 891.

C. Construct cast-in-place manholes as indicated.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops with respect to finished surface as indicated.

3.8 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.9 DOWNSPOUT BOOT INSTALLATION

A. Secure downspout boots to building walls with stainless steel anchors and fasteners.

B. Set downspout boots to accept downspouts.

C. Connect to the storm drainage collection piping with a non-shear coupling – Fernco or approved equal.

3.10 STORM DRAINAGE INLET AND OUTLET INSTALLATION

A. Construct inlet aprons and sides of reinforced concrete, as indicated.

B. Install outlets that spill onto grade, anchored with concrete, where indicated.

C. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

D. Construct riprap outfalls as indicated.

3.11 SEPARATION OF STORM SEWERS FROM WATER MAINS

A. The separation of sanitary sewer from water mains must comply with the Indiana Administrative Code, 327 IAC 3-6-9.

B. Vertical separation between utilities – a minimum of 18 inches of vertical separation shall be maintained between all utilities unless otherwise indicated on the plans or unless written permission is given by the Engineer. Sewers crossing water minas shall be laid to maintain a minimum vertical clearance of 18 inches between the outside of the water main and the outside of the sewer main.

C. Horizontal separation between utilities – a minimum of 10 feet horizontal separation shall be maintained between all utilities unless otherwise indicated on the plans or unless written permission is given by the Engineer.

3.12 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318/318R.

3.13 CONNECTIONS

A. Make connections to existing piping, storm structures, and manholes as indicated.

3.14 CLOSING ABANDONED STORM SEWER SYSTEMS

A. Completely remove all piping, manholes, and other structures as indicated unless specifically noted otherwise.

B. Backfill to grade as indicated and according to Division 31 Sections "Earth Moving" and “Excavation and Fill.”

3.15 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use detectable warning tape over all piping and over edges of underground structures.

B. Include a continuous #12 insulated HS-CCS locate wire along the piping if indicated. All laterals, footing drain extensions, and underdrain extensions shall include locate wire. The wire shall be wrapped around the pipe so that a minimum of one revolution is made at least every pipe joint. Wire shall be extended and exposed in manholes, catch basins, and cleanouts.

3.16 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:
    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 95 percent of piping diameter.
    c. Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.

4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
    a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
    b. Option: Test plastic piping according to ASTM F 1417.
    c. Option: Test concrete piping according to ASTM C 924.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.17 CLEANING

A. Clean interior of piping of dirt and superfluous materials.

3.18 STORMWATER DETENTION SYSTEM

A. Pipe System: Install as indicated per manufacturer’s written instructions.

END OF SECTION 334000

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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 subdrainage systems for the following:

1. Foundations.
2. Retaining Walls
3. Detention Basin Subdrainage

1.3 DEFINITIONS

A. HDPE: High-density polyethylene plastic.

B. PE: Polyethylene plastic.

C. PVC: Polyvinyl chloride plastic.

D. Subdrainage: Drainage system that collects and removes subsurface or seepage water.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Perforated pipe and fittings.
2. Solid-Wall pipe and fittings.
3. Geotextile filter fabrics.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to the "Piping Applications" Article in Part 3 for applications of pipe, tube, fitting, and joining materials.

2.3 PERFORATED PIPE AND FITTINGS

A. Perforated HDPE Pipe and Fittings:

1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type S; corrugated, for coupled joints.
2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type S; or AASHTO M 294, Type CP; corrugated; for coupled joints.
3. Couplings: Manufacturer's standard, band type.

B. Perforated PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

C. Perforated PVC Pipe and Fittings: ASTM D 1785, Schedule 40, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

D. Perforated PVC Sewer Pipe and Fittings: ASTM F949-90, Contech A-2000 with bell-and-spigot ends or approved equal.

2.4 SOLID-WALL PIPE AND FITTINGS

A. HDPE Drainage Tubing and Fittings: AASHTO M 252, Type S, corrugated, with smooth waterway, for coupled joints.

1. Couplings: AASHTO M 252, corrugated, band type, matching tubing and fittings.

B. HDPE Pipe and Fittings: AASHTO M 294, Type S, corrugated, with smooth waterway, for coupled joints.

1. Couplings: AASHTO M 294, corrugated, band type, matching tubing and fittings.

C. PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, bell-and-spigot ends, for gasketed joints.

1. Gaskets: ASTM F 477, elastomeric seal.

D. PVC Sewer Pipe and Fittings: ASTM D 1785, Schedule 40, bell-and-spigot ends, for gasketed joints.

1. Gaskets: ASTM F 477, elastomeric seal.

E. PVC Sewer Pipe and Fittings: ASTM F949-90, Contech A-2000 with bell-and-spigot ends for gasketed joints or approved equal.

1. Gaskets: ASTM F 477, elastomeric seal.

2.5 SPECIAL PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant metal tension band and tightening mechanism on each end.

1. Sleeve Materials:
   a. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
   b. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
2. Unshielded Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant metal tension band and tightening mechanism on each end.
3. Shielded Flexible Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant metal tension band and tightening mechanism on each end.

2.6 CLEANOUTS

A. Cast-Iron Cleanouts: ASME A112.36.2M; with round-flanged, cast-iron housing; and secured, scoriated, Medium-Duty Loading class, cast-iron cover. Include cast-iron ferrule and countersunk, brass cleanout plug.

B. Copper-Alloy Cleanouts: ASME A112.36.2M; with round-flanged, cast-iron housing with clamping device; and scoriated, medium-Duty Loading class, copper-alloy cover. Include countersunk, brass cleanout plug.

C. PVC Cleanouts: ASTM D 3034, PVC cleanout threaded plug and threaded pipe hub.

2.7 SOIL MATERIALS

A. Backfill, drainage course, impervious fill, and satisfactory soil materials are specified in Division 31 Sections "Earth Moving" and “Excavation and Fill.”

2.8 ROOFING FELTS

A. ASTM D 226, Type I, asphalt or ASTM D 227, coal-tar-saturated roofing felt.

2.9 GEOTEXTILE FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

1. Acceptable Manufacturers:
   a. Propex
   b. Approved Equal

2. Referenced products to match or exceed the standards of the Propex Geotex:
   a. Geotex 401

b. Approved Equal

3. Structure Type: Nonwoven, needle-punched continuous filament or woven, monofilament or multifilament.

4. Style(s): Flat and sock.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

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

3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Sections "Earth Moving" and “Excavation and Fill.”

3.3 CLEANOUT APPLICATIONS

A. In Underground Subdrainage Piping:

1. At Grade in Earth: PVC cleanouts.
2. At Grade in Paved Areas: Cast-iron cleanouts.

3.4 FOUNDATION DRAINAGE INSTALLATION

A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches deep and 12 inches wide.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.

D. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.

E. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.

F. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and above top of pipe or as otherwise required by the Geotechnical Engineer and/or Structural Engineer to within 12 inches of finish grade.

G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

H. Place layer of flat-style geotextile filter fabric or waterproofing felt over top of drainage course, overlapping edges at least 4 inches.

3.5 RETAINING-WALL DRAINAGE INSTALLATION

A. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

B. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches.

C. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.

D. Install drainage piping as indicated in Part 3 "Piping Installation" Article for retaining-wall subdrainage.

E. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.

F. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and above top of pipe to within 6 inches of finish grade.

G. Place drainage course in layers not exceeding 3 inches in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.

H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.

I. Fill to Grade: Place satisfactory soil fill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Fill to finish grade.

3.6 DETENTION BASIN SUBDRAINAGE INSTALLATION

A. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.

D. Install drainage conduits as indicated in Part 3 "Piping Installation" Article for landscaping subdrainage with horizontal distance of at least 6 inches between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive or tape.

E. Add drainage course to top of drainage conduits.

F. After satisfactory testing, cover drainage conduit to within 12 inches of finish grade or as otherwise indicated.

G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.

I. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Fill to finish grade.

3.7 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
   1. Foundation Subdrainage: Install piping level and with a minimum cover of 36 inches unless otherwise indicated.
   2. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of 36 inches unless otherwise indicated.
   3. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 12 inches unless otherwise indicated.
   4. Lay perforated pipe with perforations down.
   5. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

C. Install PE piping according to ASTM D 2321.

D. Install PVC piping according to ASTM D 2321.

3.8 PIPE JOINT CONSTRUCTION

A. Cast-Iron Soil Pipe and Fittings: Hub and spigot, with rubber compression gaskets according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook." Use gaskets that match class of pipe and fittings.

B. Join PE pipe, tubing, and fittings with couplings for soil-tight joints according to AASHTO's "Standard Specifications for Highway Bridges," Division II, Section 26.4.2.4, "Joint Properties."

C. Join perforated, PE pipe and fittings with couplings for soil-tight joints according to AASHTO's "Standard Specifications for Highway Bridges," Division II, Section 26.4.2.4, "Joint Properties"; or according to ASTM D 2321.

D. Join PVC pipe and fittings with elastomeric seal gaskets according to ASTM D 2321-83a.

E. Join perforated PVC pipe and fittings according to ASTM D 2729, with loose bell-and-spigot joints.

F. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.9 CLEANOUT INSTALLATION

A. Cleanouts for Foundation Subdrainage:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use NPS 4 cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete block, 18 by 18 by 12 inches in depth. Set tops flush with grade. Cast-iron pipe may also be used for cleanouts in nonvehicular-traffic areas.
3. In nonvehicular-traffic areas, use NPS 4 PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete block, 18 by 18 by 12 inches in depth. Set tops 1 inch above grade.

3.10 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.

3.11 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping.

1. Install detectable warning tape over all piping and over edges of underground structures.

3.12 FIELD QUALITY CONTROL

A. Testing: After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

3.13 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 334600

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