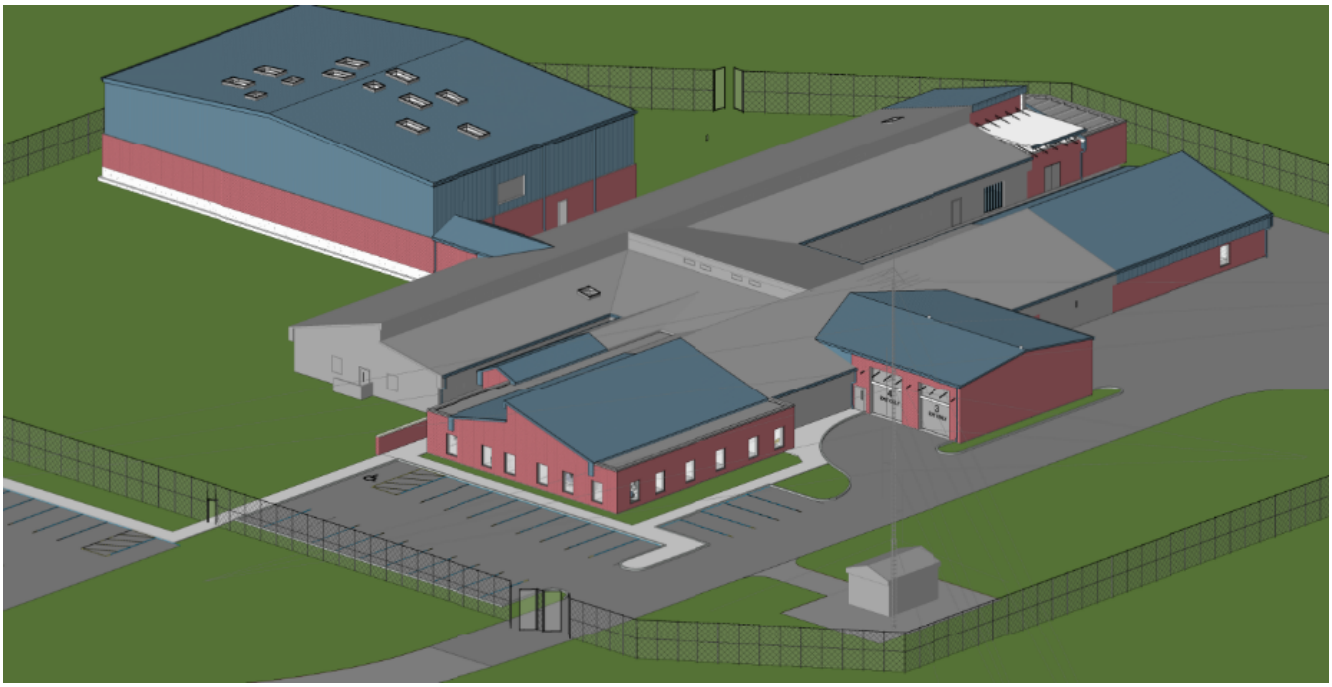

PROJECT MANUAL – VOLUME 3

VERMILLION COUNTY JAIL ADDITION & RENOVATION

BID SET PREPARED FOR

Vermillion County Board of Commissioners

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RQAW
ARCHITECTURE

VOLUME 3
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SECTION 21 05 01

COMMON WORK RESULTS FOR FIRE PROTECTION

PART 1 - GENERAL

1.1 REFERENCES

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

B. INDIANA CODES

1. General Administration Rules: Amended 12/01/2014
2. Building Code: Effective 12/01/2014
3. Fire Code: Effective 12/01/2014
4. Plumbing Code: Effective 12/24/2012
5. Electrical Code: Effective 08/26/2009
6. Mechanical Code: Effective 12/01/2014
7. Handicapped Accessibility Code: 2014
8. Energy Code: Effective 05/07/2010
9. Elevator Safety Code: 2011:
11. Fuel Gas Code: Effective 12/01/2014
12. NFPA 10
13. NFPA 13
14. NFPA 20
15. NFPA 25
16. NFPA 72

1.2 QUALITY ASSURANCE

A. Regulations and Standards: All equipment, apparatus, and systems are to be fabricated and installed in complete accordance with fire and insurance rules and regulations, the Life Safety Code, and the latest edition or revision of the following applicable regulations, standards, and codes:

1.	AIA	American Institute of Architects
2.	ASME	American Society of Mechanical Engineers
3.	ASTM	American Society for Testing and Materials
4.	NFPA	National Fire Protection Association
5.	NEC	National Electric Code
6.	OSHA	Occupational Safety and Health Administration
7.	UL	Underwriter's Laboratories, Inc.
8.	MCAA	Mechanical Contractors Association of America, Inc.
9.	ANSI	American National Standard Institute
10.	MSSV	Manufacturer's Standardization Society of the Valve and Fitting Industry
11.	AWWA	American Water Works Association

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12. NACE National Association of Corrosion Engineers
13. State of Indiana, Indiana Fire Code and Local Fire Marshal Requirements
14. Owner's Fire Insurance Agency requirements
15. Division 01 Sections “Regulatory Requirements: and “Reference Standards” of the Project Specifications
16. References on the Drawings or in the Specifications to "code" or "building code" not otherwise identified shall mean the specific codes applicable to this Project location, together with all additions, amendments, changes, and interpretations adopted by code authorities having jurisdiction over this Project.
17. The applicable edition of all codes shall be that adopted at the time of issuance of permits by the authorities having jurisdiction and shall include all modifications and additions adopted by that jurisdiction.
18. Give all required notices so as to comply with, and meet, all inspections required by Federal, State, and Local authorities.
19. It is not the intent herewith to modify, reduce, or change any rules, standards, regulations, or requirements that are applicable under local, state and federal codes, ordinances, or regulations of the various authorities having jurisdiction. Where the standards differ among the various authorities, the most restrictive shall apply. Where the requirements shown on the Drawings or called for in the Specifications exceed code requirements, these Drawings and Specifications shall take precedence. Where the requirements within the specifications of this division of work and the Drawings conflict with the referenced Divisions, Sections, and other documents, the documents having the most restrictive and the higher cost requirements shall apply.

1.3 SCOPE:

A. Perform all Work required to provide and install pipe, fittings, valves, connections, hangers, supports, sleeves and appurtenances for new, rework and/or expansion of existing wet-pipe sprinkler system with supplementary items necessary for complete, code compliant and approved installation.

B. Where piping and sprinklers are shown on drawings, such representation is for estimating and planning purposes only. It shall be the responsibility of this Contractor conduct his own **flow test**, establish his own layout, prepare shop drawings, furnish and install any additional piping or sprinklers which might be required to meet the requirements or approval of the authority having jurisdiction. Such additional installations shall be made without any additional cost to the Owner.

C. Size all branches and mains by hydraulic calculations. Contractor shall conduct a water flow test to obtain water supply information to determine actual available volume and pressures as a design basis for the system. Provide a 10 psi cushion for all hydraulic designs when possible. Hazard classifications for fire protection system design, installation and water supplies shall be in accordance with NFPA Standards. Include hose stream demand based on hazard classification.

D. Sprinkler head locations and spacing for Light Hazard Occupancies shall be in accordance with NFPA 13 requirements.

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E. Interface all new flow and valve supervisory switches with building fire and smoke alarm systems.

1.4 JOB CONDITIONS AND COORDINATION

A. Local Conditions
   1. Each Trade Contractor is to inform himself of the conditions under which the work is to be performed, the site of the work, the structure of the ground, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work to be done.
   2. Contractors shall coordinate, and review indicated utility data with the local utility companies.

B. Present Job Site Inspection
   1. Contractor is to investigate for any existing conditions and responsibilities which are not clearly defined by the Drawings and Specifications. If any such conditions exist, they shall bring them to the attention of the A/E in writing. The A/E will then make the required written clarification. The absence of questions before the opening of bids shall indicate a clear understanding of the scope of work and the Contractor's responsibility.

C. Permits and Fees: This Contractor is to obtain all permits and pay all fees required for the work under Divisions 21 of the Work.

D. Royalties and Patents
   1. The Trade Contractor is to pay all royalties and license fees. They shall defend, indemnify, and hold the Owner and A/E harmless from any and all suits, demands or claims for infringement of any patent rights.
   2. The review by A/E or Owner of any method of construction, invention, appliance, process, article, device or material of any kind is to be for adequacy of work, and is not to be construed as an approval of the use thereof by the Contractor in violation of any patent or other rights of any third person.

E. Wiring and Conduit Requirements: In general, most wiring and conduit requirements are addressed, either upon the Drawings as a part of a packaged equipment assembly specifications, or within Divisions 26, 27 and 28 of the Specifications. However, should an equipment component, panel, or system device need additional wiring and conduit so as to be complete, approved and fully operational, the Contractor who supplied the equipment component, panel or system device shall be responsible for the required wiring and conduit as well as circuit disconnect and protection for same when it is not otherwise covered by the Project Drawings and Specifications.

F. Coordination: Coordinate the exact location of this work with the work of other trades prior to fabrication or installation of same. Verify all dimensions and elevations. Provide additional offsets and sections of material as may be required to meet the applicable job condition requirements. Coordinate with and review all related construction Drawings and Shop Drawings of all equipment suppliers prior to start of work.

G. Post Indicating Valve: Furnished and Installed by the Civil Contractor.

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H. **Fire Pump**: If a fire pump is not indicted on the project documents and the bidding contractor determines that a fire pump is required to meet code compliance. Such Contractor shall immediately notify the Architect /Engineer to resolve the issue and to include such determination in the next addendum. If the Contractor discovers the need for a fire pump after the last issuance of the addendum, the Contractor shall clearly qualify his bid prior to bids being received.

1.5 SPECIFICATIONS AND DRAWINGS

A. These specifications and Drawings are intended to describe and provide for a complete and finished project. They are intended to be complementary. All items of work called for by either shall be as binding as if called for by both. The work described shall be complete in every detail, notwithstanding the fact that every item necessarily involved is not particularly mentioned or shown. If the Bidder, Supplier or Contractor sees anything to question, it must be brought to the attention of the A/E immediately.

B. Minor Deviations: The Drawings accompanying these Specifications indicate the general design and arrangement of equipment, apparatus, fixtures, accessories and piping necessary to complete the installation of the system. The exact location or arrangement of the apparatus and equipment, unless otherwise dimensioned, is subject to minor changes necessitated by field conditions and shall be required without additional cost to the Owner. Measurements shall be verified through actual observation at the construction site. Each Trade Contractor shall be responsible for fitting all of their work into place in a satisfactory and workmanlike manner, to the approval of the A/E and Owner.

C. Provide all labor and materials necessary for the completion of the work described. Referenced codes and industry standards and methods shall apply when no other specifics are indicated. Bring questions relating to this paragraph to the attention of the A/E for resolution prior to the receipt of Bids.

D. All Work indicated on Drawings, diagrams, or details in part only are to continue throughout unless distinctly marked otherwise. The same applies to other parts of the project where merely a typical reference plan, diagram, or section of the drawing is complete. The balance is intended to be the same as the typical plan, section, or diagram as shown and is to be figured accordingly.

E. The specifications are divided into trades and divisions only for the distinct purpose of facilitating the work. However, the Trade Contractor will become responsible for furnishing all labor and materials necessary to complete the project as contemplated by the Drawings and Specifications. Any item mentioned under any heading of the Specifications must be supplied even though it is not called for again under the heading for the respective work.

F. Should discrepancies occur within the Contract Documents, the more stringent and more costly approach shall apply for bidding purposes. The Contractor is to notify the A/E of discrepancies for clarification. Clarifications issued after the Contract is awarded shall be incorporated by the Contractor at no additional costs and shall be reviewed by the A/E to determine if a reduction in cost is justified.

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G. Typically, the Fire Protection Contractor is to begin his work at the piping blind-flange located at 18" A.F.F. The blind-flange is to be provided and installed by the Plumbing Contractor.

1.6 OPERATIONAL AND MAINTENANCE INSTRUCTIONS

A. All operational and maintenance instructions that are provided to various Owner-selected members of the facility engineering and/or maintenance staff are, at the same time presented, to be fully recorded on DVD by the Contractor so that all such sessions can be later reviewed by the Owner's staff on a retraining basis as needed. All such DVDs are to become the property of the Owner at the end of each applicable training period, with one copy of each also being supplied to the A/E for the A/E project files.

PART 2 - PRODUCTS

2.1 MANUFACTURERS/PRODUCTS/SUBMITTALS

A. Under the Base Bid, no other manufacturers except those indicated on the Drawings or those listed within the Sections of this Division, that are, in turn, able to comply with the contract document requirements and minimum standards of these specifications, will be acceptable. In addition to specific required "Alternates," proposed substitutions that may or may not be acceptable to the Owner may be submitted by the Contractor only at the time of initial base bid submittal.

B. Although design-based models of various manufacturers may be indicated within the various schedules, it is the responsibility of the various equipment manufacturers to verify the model selections so that all items of equipment comply with the minimum standards of performance that are indicated within the schedules, as well as the requirements within various sections of the specifications under which the equipment is also specified.

C. All submittals shall conform completely to the requirements of the Contract Documents, including all requirements set forth in Division 01 Section "Submittals".

D. Shop Drawing are to be submitted on each item of specified or scheduled equipment, valves, specialties, insulation, fixtures, drains, controls and related accessories. All control submittals must include a typed sequence of control for each system.

2.2 ACCESS DOORS AND PANELS

A. Unless otherwise indicated, each Trade Contractor is to locate and furnish all access doors required for non-accessible surfaces (such as ceilings, walls, chases, and similar locations), so that all valves and similar items are easily accessible for operation, inspection and maintenance. Access doors for ceiling, walls, chases, etc. are to be installed by the General Contractor. The Trade Contractor is to bear the costs of the installation of the access doors.

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B. See Division 08 Section “Access Doors and Frames” for access door types and specifications. Minimum size to be 12 inch x 12 inch, or as indicated or required to allow inspection of items served.

2.3 SLEEVES

A. Each Contractor is to provide properly sized, secured and firestopped sleeves for all of their piping systems at all penetrations of walls, foundations, partitions, floors and roofs throughout the entire facility.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide all materials, labor, equipment, and services necessary for a complete and operable installation as specified and shown on the Drawings. The word "Provide" shall mean "Furnish and install."

B. Provide new material and equipment in strict accordance with these Specifications and the Project Drawings.

C. At all times, take such precautions as are necessary to protect materials from damage. Close all pipe openings to prevent obstructions and contamination.

3.2 CUTTING AND PATCHING IN BUILDINGS

A. Each Contractor is responsible for all costs associated with the necessary cutting and patching as required for the installation of their work, unless otherwise indicated.

B. Patching is to be performed by the trade proper for each material to be patched. Patching shall leave premises and finishes in a complete and neat condition comparable to the original. Painting of patched surfaces to be by the painting sub-contractor of the General Contractor, unless otherwise specifically indicated or the plumbing/fire protection contractor is the prime contractor for the project. Maintain the fire integrity of all walls, floors, ceilings, and partitions.

3.3 PROTECTION

A. Protect equipment and trim against damage and injury due to building materials, acid, tools, equipment and any causes incidental to construction. Cover the finished surface of each piece of equipment with building paper or similar protection. Replace all equipment damaged by any cause and any trim with marred or scratched finish at no cost to the Owner, upon receipt of written notification from the A/E.

B. Where materials to be installed are being stored at or near the project during construction, arrange such materials so as to minimize the possibility of contamination, corrosion and damage. Keep ends of pipe, equipment, and specialties properly closed

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during construction and installation to avoid the possibility of miscellaneous materials being placed in the openings.

C. Protect sprinklers from dust, dirt and paint spray during construction with temporary sprinkler covers.

3.4 PAINTING

A. See Division 09 Sections.

3.5 ADJUST AND CLEAN

A. Inspect all equipment and put in satisfactory working order.

1. Clean specialties and devices.
1. Clean all covers.
2. Clean exposed piping.
3. Remove temporary sprinkler covers and clean sprinklers.

3.6 OPERATIONAL TEST

A. Upon completion of and prior to acceptance of the installation, the Contractor shall subject the fire protection system to operating tests in accordance with NFPA.

END OF SECTION 21 05 01

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SECTION 21 05 29

HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. Work of this Section includes, but is not limited to: Pipe hanger and supports, Pipe and equipment anchors, Pipe sleeves.

1.3 QUALITY ASSURANCE

A. Pipe Hanger Standards: Manufacturers Standardization Society (MSS) SP-58, SP-89, and SP-69, as referenced.

B. SMACNA.

C. NFPA

1.4 SUBMITTALS

A. Shop Drawings: Miscellaneous steel layout. Indicate all point loads where miscellaneous steel is supported by structural members, Brace spacing, layout, connection method and details.

B. Product Data: Catalog cuts and performance data.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

E. Contract Closeout Information: Operating and maintenance data, Warranty.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

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A. Pipe Hangers: Elcen Metal Products Co., B-Line Systems Inc., Carpenter and Paterson Inc., Anvil.

B. Concrete Anchors: Phillips, Hilti.

C. Pipe and Equipment Anchors: Shop-fabricated, Field-fabricated.

D. Sleeves: Shamrock Industries, "Crete-sleeve" plastic hole forms, Proset Systems Inc., "Proset" fire-safe pipe penetrations, Shop for field fabricated.

E. Sleeves, Pre-Manufactured Fire and Smoke Wall Barrier: Pipe Shields, Inc.

2.2 PIPE HANGERS AND SUPPORTS

A. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Cadmium plated carbon steel, adjustable swivel split ring. Use PVC coated or copper plated for copper piping.

B. Hangers for Pipe Sizes 2 to 6 Inches and Over: Carbon steel, adjustable, clevis type. Use copper plated for copper piping.

C. Hanger for fire protection piping shall be UL listed and FM approved.

D. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

E. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp; adjustable steel yoke and cast iron roll for hot pipe sizes 6 inches and over.

F. Vertical Support: Steel riser clamp.

G. Floor Support for Pipe Sizes to 8 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.

2.3 HANGER RODS AND ATTACHMENTS

A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded. Use cadmium plated rods where unconcealed or exposed to the elements.

B. Minimum pipe hanger rod sizes are as follows:

Pipe Size	Rod Diameter
Up to 2 Inches	3/8 Inch
2-1/2 Inches & 3 Inches	1/2 Inch
4 Inches	5/8 Inch
6 Inches	3/4 Inch
8 Inches to 12 Inches	7/8 Inch

C. For fire sprinkler systems, conform to latest NFPA standards required by OBC.

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D. Beam Clamps (up to 8-inch diameter pipe): Top beam clamp, steel jaw, hook rod with nut and spring washer steel eye-bolt. C-clamps by themselves are expressly prohibited unless otherwise approved by Structural Engineer

2.4 INSERTS

A. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.5 PIPE SLEEVES AND SEALANTS

A. Sleeves – General: Sleeve all piping passing through walls, floors, roofs, foundations, footings and grade beams sufficient to allow free movement of piping. Box out openings larger than 14 inch diameter.

B. Sleeves, Steel Pipes: Use in following locations:
   1. Fire-rated and smoke-rated construction.
   2. Structural steel members (when approved by A/E).
   3. Floors: Galvanized.
   4. Concrete walls.
   5. Mechanical rooms, tunnels, and stairwells.
   6. Polyethylene hole forms (Crete-Sleeve): Optional use in poured concrete walls and floors.

C. Sleeves, pre-manufactured fire and smoke wall barrier: Optional, similar to Pipe Shields, Inc. Bare Pipe through Fire Walls and Floors: Model WFB, DFB, or QDFB.

D. Sleeve Sizes: Length: Ends flush with finished surfaces, Diameter: Minimum 3 inch, Minimum 1 inch larger than pipe and pipe insulation, In concrete, 1-1/2 inch larger than pipe, Diameter suitable for construction tolerances and to receive sealant, when indicated.

E. Sealants: Seal annular space around piping.
   1. For fire- and smoke-rated floors, walls and partitions: Use UL-listed firestopping material that maintains fire-rated wall and floor integrity. Provide proper material for each typical application as described by manufacturer.
   2. Acceptable Manufacturers: Dow Corning "Fire Stop", Nelson "Flameseal", 3M "Fire Barrier", Pipe Shields Inc., Model WFB, DFB, or QDFB Series, Proset Systems.
   3. For Non-Rated Walls and Partitions: Use mineral or glass fiber insulation.
   4. For Exterior and Foundation Walls: Use synthetic rubber seals, "Link-Seal" waterproof material or system.

PART 3 - EXECUTION

3.1 GENERAL

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A. Structural Considerations: Steel or concrete roof/floor system, including slabs or roof deck shall be in place and complete before installation of any mechanical piping system. Space hangers so maximum individual hanger load will not exceed values listed in paragraph "Pipe Hanger Loading." Do not attach hangers to steel roof deck. Do not attach hangers to bottom of concrete filled floor deck, except by permission of A/E. Attach hangers to beams whenever possible.

B. Install piping systems with approved hangers and supports to prevent sagging, warping and vibration of piping systems. Install pipe hangers and supports to allow for expansion, contraction, and drainage of piping. Place hangers and supports close to valves, vertical riser drops, heavy equipment, specialties, and each piping change of direction.

C. Connect hanger rods to approved "I" beams or channel clamps, concrete inserts or expansion shields. Provide all concrete inserts and structural members required for the proper support of the piping systems with proper approved distribution of weight.

D. Do not weld to structural steel without special permission of the A/E. Do not use wooden plugs for any form of fastening.

E. Space pipe hangers for horizontal piping as indicated, unless otherwise directed. Provide pipe hangers with the minimum rod sizes shown, complete with full length machined threads, and adjusting and lock nuts.

F. Run piping substantially as shown on the Drawings. Run pipe as directly as possible, avoiding unnecessary offsets and interferences, maintaining maximum headroom and concealed in all rooms or areas, except mechanical equipment rooms, unless otherwise noted. Coordinate exact locations of mains, risers and runouts in the field with the various Trade Contractors and the A/E.

G. Assemble and install piping without undue strain and stress and with provision for expansion, contraction and structural settlement. Do not cut or notch structural members unless adequate provision is made with the approval of the A/E. Anchors shall be approved by the A/E before they are used.

3.2 PIPE HANGERS AND SUPPORTS

A. Provide a hanger within one (1) foot or less of each horizontal elbow and valves that are above three (3) inches in size. If spacing between horizontal elbows (or plugged tees used as elbows) is less than six (6) feet, provide only one (1) hanger located between the elbows. No hanger size or requirements shall ever be less than the minimum recommended by the Mechanical Contractor's Association of America, Inc.

B. For fire protection piping, space according to NFPA Section 13.

C. For piping of other materials, space hangers according to manufacturer's recommendations.

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D. Pipe Hanger Loading: Total hanger rod load (including piping, insulation, and fluid) not exceeding following limits, do not exceed manufacturer's recommended maximum safe load if smaller than below:

Nominal Rod Diameter	Maximum Load
3/8 inch	610 lb.
1/2 inch	1,130 lb.
5/8 inch	1,810 lb.
3/4 inch	2,710 lb.

E. Trapeze Hangers: Suspend trapeze hangers from concrete inserts of approved structural clips. Construct trapeze hangers of galvanized angle iron, channels or other structural shapes with flat surfaces for point of support.

F. Vertical Pipe Supports: Support all vertical pipe runs in pipe chases at base of riser. Support pipes for lateral movement with clamps or brackets.

G. Concrete Inserts: Provide individual or continuous slot concrete inserts for use with hangers for piping and equipment exposed in finished areas, and as required. Provide concrete inserts in time for installation in concrete.

3.3 ANCHORS

A. All connections to the structure shall be sized according to actual applied load plus any seismic vertical component increase.

B. Pipe Anchors: Provide as indicated and required to permit complete installation of system. Do not anchor piping to plaster or gypsum wallboard partition walls. Provide anchoring devices at locations indicated. Do not use powder driven fasteners, expansion nails, or friction spring clamps.

3.4 SLEEVES

A. Coordinate location of any opening in structural systems with A/E and other trade contractors.

B. Maintain rating of fire- and smoke-rated construction.

C. Set sleeves plumb or level, in proper position, tightly fitted into the work.

D. Set all sleeves with ends flush with finished wall and ceiling surfaces.

E. Seal around all pipes and use firestopping for all mechanical penetrations through floor slabs, fire rated walls and partitions, and at each floor level in vertical mechanical service shafts. Install firestopping as described in manufacturer's installation instructions.

F. Seal around all sleeves.

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G. Fill openings made by others for piping penetrations, with same construction as work opening is in, or construction of equivalent fire or smoke rating.

3.5 MISCELLANEOUS STEEL

A. Piping Contractor (or Fire Protection Contractor, as applicable) to provide all miscellaneous steel as required to accommodate pipe supports and hangers.

B. Provide Shop Drawings detailing miscellaneous steel layout and connection to structural members. Indicate all point loads where miscellaneous steel is supported by structural members.

C. All miscellaneous steel to be galvanized steel. Repair galvanized steel at field cuts and connections.

END OF SECTION 21 05 29

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SECTION 21 05 53

PIPE AND EQUIPMENT IDENTIFICATION

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. Work of this Section includes, but is not limited to: Piping identification, Valve identification, Equipment identification.

1.3 QUALITY ASSURANCE

A. Piping System Identification: ANSI A13.1-1981, "Scheme for the Identification of Piping Systems."

1.4 SUBMITTALS

A. Shop Drawings: Not required for review.

B. Product Data: Manufacturer's cut sheets and/or literature.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

E. Contract Closeout Information: Valve chart showing valve numbers, type, and location.

PART 2 - PRODUCTS

2.1 PIPE MARKERS

A. Conform to ANSI A13.1-81.
   1. Pressure-sensitive vinyl (self-sticking) material.
   2. Mechanically Fastened Type: Snap-on or strap-on. For dirty greasy, oily pipe where pressure-sensitive markers may not perform satisfactorily.
   3. Provide with direction of flow arrows.
   4. Size of Letters Legend

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Outside Diameter of Pipe or Pipe Covering	Length of Color Field	Size of Letters and Arrows
3/4 to 1-1/4 inch	8 inch	1/2 inch
1-1/2 to 2 inch	8 inch	3/4 inch
2-1/2 to 6 inch	12 inch	1-1/4 inch
8 to 10 inch	24 inch	2-1/2 inch
Over 10 inch	32 inch	3-1/2 inch

2.2 VALVE TAGS

A. Brass or Anodized Aluminum Type
   1. Brass: Minimum 19 ga, polished, 1-1/2-inch diameter with following lettering: Service: 1/4 inch stamped black filled letters. Valve numbers: 1/2 inch stamped black filled letters.
   2. Aluminum: 2-inch diameter, 0.032 inch thick, with following lettering: Service: 1/4 inch engraved letters. Valve numbers: 1/2 inch engraved letters.

B. Valve Tag Fasteners: 4-ply 0.018 copper or monel wire meter seals, brass "S" hooks or No. 16 brass jack chain.

2.3 EQUIPMENT NAME PLATES

A. 1/16-inch rigid plastic "Setonply," "Emedolite," or bakelite with 4 edges beveled, or engraved aluminum with black enamel background and natural aluminum border and letters. Two 3/8-inch mounting holes. Lettering size: Minimum 1/2-inch high. Fasteners: Commercial quality, rust-resisting nuts and bolts with backwashers and self-tapping screws or rivets.

2.4 CHART AND DIAGRAM FRAMES

A. Extruded aluminum with plexiglass or glass windows.

2.5 ACCEPTABLE MANUFACTURERS

A. Pipe, Valve, and Equipment Markers: Craftmark Identification Systems, W. H. Brady Co., EMED Company, Inc., Kolbi Industries, Inc., 3M Co., Seton Name Plate Corp.

PART 3 - EXECUTION

3.1 VALVE AND EQUIPMENT IDENTIFICATION

A. Designate all equipment and valves by distinguishing numbers and letters on charts and/or diagrams. Tag and locate following equipment items: Valves, All items indicated on drawing equipment schedules.

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B. Install tags on all devices with numbers and letters corresponding to charts.

C. Fasten tags securely to devices with tag fasteners in manner for easy reading.

D. Attach equipment nameplates in conspicuous location on item of equipment or apparatus such as starters, pumps, and control panels. Secure nameplates with self-tapping screws, or nuts and bolts.

E. For unsuitable conditions, such as high temperature or lack of space, use copper or brass rings or chains to attach tags.

F. Furnish 4 charts including device number, location (room number, department) and purpose. Mount 1 chart in frame and secure on wall in location directed by Owner. Include remaining 3 sets in "Operation and Maintenance Manuals."

G. Provide all devices located above ceilings with additional identification. Use access panel markers (metal-tack-style) for acoustical tile ceilings, or engraved plastic style, 3/4 inch square, for mounting on panel door. Coordinate with Owner on identification method and color codes.

3.2 PIPE IDENTIFICATION

A. Locate pipe markers as follows:
1. Next to each valve and fitting, except on equipment.
2. At each branch or riser take-off.
3. At each passage through walls, floors, and ceilings.
4. At each pipe passage to underground.
5. On all horizontal pipe runs every 20 feet, at least once in each room and each story traversed by piping system.
6. Identify piping contents, flow direction.

B. Install markers with tape color bands over each end of marker, extending around pipe and overlapping a minimum of 30 degrees.

3.3 SERVICE ABBREVIATIONS

A. General

1.	S	Sprinklers
2.	F	Fire Protection

END OF SECTION 21 05 53

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SECTION 21 13 13

WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

B. Fire and Building Safety Regulations

1. Indiana Building Code - 2014 edition
2. Indiana Fire Code – 2012 edition
3. NFPA 13 – 2010 edition

1.2 DESCRIPTION OF WORK

A. Fire protection systems include: All Work required to provide and install pipe, fittings, valves, connections, hangers, supports, sleeves and appurtenances for new, rework and/or expansion of existing wet-pipe sprinkler system with supplementary items necessary for complete, code compliant and approved installation.

B. It shall be the responsibility of this Contractor to establish his own sprinkler layout, prepare shop drawings, furnish and install his sprinkler design to meet the requirements or approval of the authority having jurisdiction.

C. Correctional Projects:
Fire Zones - POD - Inmate Cells: Shall be served from a manual wet-pipe sprinkler system which is supervised and manually controlled by the 24/7 stationed jail staff. Typically, the sprinkler piping serving the cell areas shall be void of water to reduce the chance of inmate tampering and willful sprinkler discharge. Inmate cell areas shall be capable to receive an alarm from either a smoke detector or low air/nitrogen pressure alarm (tampering) which then notifies the jail staff of a potential problem. The jail staff can then determine if the alarm is valid and manually open the sprinkler control valve or valves which are located within the Control Room, to charge the sprinkler piping with water.

Fire Protection Systems That Serve POD Building: Shall be one wet-pipe zone with supplementary items necessary for complete, code compliant and approved installation.

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1.3 QUALITY ASSURANCE

A. Design Criteria
1. Provide complete fire protection system as required by regulations adopted by the Indiana Fire Prevention and Building Safety Commission and local fire safety authorities.
2. Where there is conflict between Fire Prevention and Building Safety requirements or other agencies' and these drawings and specifications, requirements of Fire Prevention and Building Safety shall govern.
3. Design and install entire system in accordance with adopted codes, standards and regulations.
4. Contractor shall hydraulically calculate sprinkler system in accordance with NFPA 13, based on hazard encountered. Hydraulic calculations shall be based on flow test which have been conducted within the last six months with a safety (reserve) factor of 5 psig or 10% of system, whichever is greater.
5. Do not downsize piping indicated to serve future areas.
6. Drawings are diagrammatic only to indicate rooms/areas of sprinkler protection and piping clearances when appropriate.
7. Submit proposed layout and flow calculations for obtaining an State Design Release prior to shop drawing submittal.
8. Submit shop drawings including equipment and piping design to RQAW for review.
9. Coordinate head locations with ceiling layouts.
10. Provide a Floor Control Valve Assembly at each floor level.
11. Control Valve Assembly is to include supervised control valve, water flow switch, inspection test valves, site glass and drain.

B. Water Supply Requirements: Fire flow to meet local fire department approved ordinances and State requirements. Fire protection contractor shall pay and arrange for certified fire flow test to be performed near the point of connection as required. Deliver three copies of certified flow test to the A/E and one to Owner's insurance company.

C. Hazard Class: Refer to Contract Drawings for sprinkler protection requirements and hazard classification. Indicate classification of all sprinkled spaces on shop drawings.

D. System Standards
1. NFPA 13, Sprinkler Systems.
2. NFPA 24, Installation of Private Fire Service Mains and Their Appurtenances.
3. State and Local Inspection Agency (Building Code Dept.).
4. State and Local Fire Marshal's requirements.
5. State Fire Code.
6. Owner's insurance company or loss prevention division.

E. Installer's Qualifications
1. The systems are to be designed and installed by a State-certified firm regularly engaged in the design and installation of automatic fire protection systems in accordance with the requirements of the National Fire Protection Association and the State, and by the authorized Insurance and Reviewing Agents of the Owner. Evidence to support the above requirements is to be provided, and any proposed installer who cannot show suitable experience will be rejected.

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2. The term qualified means experienced in such work with NICET Level 3 or 4 certification. Experienced shall also mean having a minimum of 5 previous projects similar in size and scope to this Project. Upon request, submit evidence of such qualifications to the A/E and Owner.

1.4 SUBMITTALS (SEE DIVISION 01)

A. Shop Drawings: Complete layout of fire protection system approved by all agencies having jurisdiction. Shop Drawings of sprinkler systems are to include detail piping plans, sections, control valves, fire department connections, sprinkler heads, and other equipment used. Site plans indicating underground supply connections, fire department connections, valves, etc. Hydraulic calculations per NFPA 13 -2010 edition,

B. Product Data: Submit product data for all components, equipment, etc. specified in this Section, Catalog cuts, Performance data. Submit to RQAW for review to determine conformance with plans and specifications, Fire and Building Safety requirements.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

E. Contract Close-Out Information: Operating and maintenance data, Owner instruction report, Test Reports: Certification that all tests as indicated in paragraph "Field Quality Control" have been successfully completed and accepted by all authorities having jurisdiction, Guarantees/Warranties. Provide detailed plans, calculations and signage as required by NFPA 13 – 2010 edition.

1.5 JOB CONDITIONS

A. Arrange and pay for all permits, fees and inspections required by both local and State jurisdictions. If a local Fire Inspection Program is not in place, contractor shall pay State Inspector fees.

B. Fire sprinkler contractor is responsible for defining all required electrical connections to the Fire Alarm Panel with the electrical contractor. Electrical contractor will perform electrical installation of conduit and wire.

C. Coordinate the exact location of this work with the work of other trades prior to fabrication and installation. Verify all dimensions and elevations. Provide additional offsets and section of piping as required to meet job conditions. Coordinate with and review all related Drawings of all trades prior to start of work.

D. All applicable switches shall be provided by this Contractor. In addition, it shall be the responsibility of this Contractor to review the scope of work and extent of related items that are presently included to be wired by the Electrical Contractor within the electrical part of the specification and drawing documents.

E. Any additional flow, tamper, pressure or other related switches that are not presently within the Electrical Contractor's scope of work shall be properly wired, per required

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codes etc., by this Fire Protection Sprinkler Contractor and shall also include wiring or same to existing and/or new fire alarm panels along with providing any and all required electronic I/O device or I/O card (addressable device if applicable), final connectors, etc., for a complete, operable and approved system.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS, AND HANGERS

A. Fire Sprinkler Piping Above Ground:

PIPING 2" AND LARGER: Black steel Rolled-Groove – Schedule 10.

PIPING LESS THEN 2": Black steel, Schedule 40, Rolled-Groove or threaded joints, malleable iron couplings.

B. Fire Sprinkler Piping Below Ground: Ductile cast iron, lined and coated, with mechanical joint fittings.

C. Pipe Hangers: All purpose type. Comply with Division 21 Section "Hangers and Supports for Fire Protection Piping and Equipment". Space in accordance with requirements of NFPA. Hangers, hanger rods, inserts and clamps constructed as approved by NFPA 13.

2.2 VALVES AND HOSE CONNECTIONS

A. Valves and Hose Connections - General
1. UL- and/or FM-approved.
2. Minimum 175 psi class.
3. Outlet/inlet threads to fit local fire department standards.
4. Finish (including accessories, caps and wall plates): Polished brass.

B. Gate Valves
1. 2 inch and Smaller: 175 lb. UL-FM bronze, non-shock, solid wedge, OS&Y gate valve. Replaceable bronze wedge facing rings. Valve to be capable of being repacked under pressure with valve wide open. Screwed ends.
2. 2-1/2 inch and Larger: 175 lb. UL-FM iron body non-shock, solid wedge, OS&Y gate valve. Replaceable wedge facing rings and yoke bonnet. Valve to be capable of being repacked under pressure with valve wide open. Flanged ends.

C. Butterfly Valves: 2 inch and Larger: 300 lb. UL-FM iron body butterfly, O-ring seat, alum-bronze or nickel-plated ductile iron disc, stainless steel stem, Buna-N seal, flanged.

D. Check Valves: 2-1/2 inch and Larger: 250 lb. UL-FM iron body check, Buna-N seat, spring-actuated, wafer-style, or grooved-end body.

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E. Vertical Post Indicator Valve: Indicates if valve is in the open or shut position. 175 lb. UL-FM iron-body gate, solid wedge disc, non-rise stem, indicator post flange, window plate OPEN and SHUT, 5-inch sleeve. Fire Protection Contractor to coordinate location of valve with Civil Contractor and local Fire Department authority.

F. Wall Mounted Indicator Valve: Indicates if valve is in the open or shut position. 175 lb. UL-FM iron-body gate, solid wedge disc, non-rise stem, indicator post flange, window plate OPEN and SHUT, 5-inch sleeve. Fire Protection Contractor to coordinate location of incoming fire service with Plumbing Contractor.

G. Fire Department Connections (FDC):
1. Fire Protection Contractor to coordinate location of valve with Civil Contractor and local Fire Department.

H. Automatic Ball Drip Valve: Straight or angle cast brass ball drip, 1/2-inch, Mount on fire department connection side of check valves and fire pump test header OS&Y valve, Potter-Roemer 5981 or 5983.

I. Alarm Check Valve: 300 lb. UL-FM iron body, cast iron bronze clapper, neoprene O-ring seal, tapped bosses for and with water pressure gages, alarm test valve, main drain valve, alarm retarding chamber, Include angle valves, globe valves, alarm line strainer, orifice restriction, pipe nipples and fittings.

J. Alarm Test Device: Single device or unit that provides visual verification of waterflow (as required by NFPA 13) in a fire sprinkler system and allows for draining of a floor section, UL-listed and FM-approved, Contains sight glass, inspector test valve, auxiliary drain valve and test orifice, Optional replacement for conventional alarm test loop, Victaulic "TestMaster".

K. Double Check Detector Assembly: UL and FM approved, size as indicated on the Drawings, Epoxy coated ductile iron valve bodies (2 checks and 2 gates), replaceable bronze seats, stainless steel internal parts, 175 psi; UL/FM resilient seated OS&Y gates, spring check valves, Provide assembly with cubic feet per minute, Ames – Colt Series.

L. Exterior Control Valves (PIV) and Fire Department Connection shall be provided and installed by the Site/Civil Contractor.

2.3 ALARM AND SIGNAL DEVICES

A. Waterflow Detector: Vane type flow switch with retard mechanism or manual adjustment to prevent false alarm, 175 psi rated, 115 VAC rated for pilot duty only, Suitable for a minimum working pressure of 175 psi, Provide with contacts for remote signal wiring, Potter VSR-F, Provide separate contacts for alarm bell and fire alarm systems.

B. Alarm Bell: Audible horn alarm signal; electrically operated, UL listed, 115 VAC, For use with waterflow detector systems, 10 inch bell.

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C. Valve Tamper Switch: To monitor the open position of an OSY Type control valve. 115 VAC/ 30 VDC, Switches for Butterfly Valves: Approved type, Two sets of SPDT contacts. Potter – OSYSU

D. Pressure Switches: Pressure activated switch designed to detect an increase and/or decrease from normal system pressure. Adjustable switch is set for 40 PSI normal system pressure, or as determined by Fire Protection Contractor. Device shall be mounted in the upright position. Potter – PS40 Series.

E. Pressure Gages: 3-1/2-inch dial glass face, black aluminum case, 1% accuracy, bronze tube, brass socket, range 0 to 250 psig. Provide a 1/4-inch gauge cock, Optional Manufacturers: Ashcroft, Trerice, Marshalltown, or Jay.

2.4 SPRINKLERS

A. Sprinklers - General
1. Provide sprinklers of type required for service indicated.
2. Standard 165 deg F rating except when application requires higher rating.
3. All sprinklers to be UL and/or FM listed as required for Project.
4. Metallic fusible link or glass-bulb-type.
5. Head Application
   a. Rooms without ceilings: Type 1.
   b. Finished Rooms: Type 2.
   c. Areas with Inmate access: Type 6
6. Provide sprinklers with 1/2-inch orifice unless specifically noted otherwise.

B. Sprinkler Type 1: Upright or pendant design as required, Standard bronze finish.

C. Sprinkler Type 2: Adjustable flush concealed, white ceiling plate flush with finished ceiling, 1/2 inch housing adjustment, Chrome finish.

D. Sprinkler Type 3: Horizontal sidewall design, Satin chrome finish.

E. Sprinkler Type 4: Extended coverage horizontal sidewall design, Satin chrome finish.

F. Sprinkler Type 5: Dry-pipe barrel, pendent design, chrome finish.

G. Sprinkler Type 6: **Institutional, pendent and horizontal sidewall, extended coverage. Install in all areas subject to physical abuse by inmates, sprinklers shall be Tyco "Raven".**

H. Tools: Furnish one emergency rubber ball shut-off on long handle to be used for temporary closing of sprinkler head after fire has been extinguished.

I. Sprinkler Cabinet: Provide spare heads of each type and sprinkler wrench for each type in quantity required by NFPA 13.

J. Sprinkler Guards: Heavy-duty welded wire, Red baked enamel finish, Reliance Model B, sprinkler guards, Provide for all heads in electrical, telephone, communication, and mechanical rooms.

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2.5 FLEXIBLE SPRINKLER DROPS

A. Fire Protection Contractor may elect at his option to install a flexible UL rated, braided hose for final connection to ceiling mounted sprinklers.

B. Size braided hose to provide at least the minimum required flow rate for the sprinkler.

C. Flexible braided hoses shall not exceed 5.0 feet in total length.

D. Flexible braided hose that supply water to cell sprinklers shall not exceed 30” in total length and shall be installed to allow for hose / pipe drainage.

2.6 ACCEPTABLE FIRE PROTECTION MANUFACTURERS

A. Alarm Valves, Wet Systems, and Deluge Valves: Reliable, Grinnell/Gem, Globe Fire Equipment Co., Star Sprinkler Corp., Viking Corp., Victaulic.

B. Alarm and Signal Devices: Federal Signal Corp., Potter Electric Signal Co., United Electric Controls Co., Viking, Grinnell, Simplex, System Sensor.

C. Sprinklers: Tyco Fire Products, Viking Corp., Reliable.

D. Backflow Preventers: Ames, Wilkens, Febco.

E. Valves: Crane, Nibco, Mueller, Homestead, Stockham.

F. Flexible Braided Sprinkler Hoses: EasyFlex, VicFlex, FlexOne.

2.7 NITROGEN GENERATING SYSTEM

The NFPA 13 Standard requires that all fire sprinkler system piping be hydrostatically tested during commissioning as proof of leak integrity. As a result of the hydrostatic testing there is always some amount of residual trapped water remaining within the piping system. The persistently moist, oxygenated condition that exists within the sprinkler piping creates ideal conditions for the corrosion of the black steel pipe. One effective means for controlling oxygen corrosion within the sprinkler systems is to eliminate oxygen from the system and prevent its introduction to the system. Using nitrogen gas in the piping system process will control oxygen corrosion.

Contractor shall provide and install all required labor, materials, equipment and services necessary for a complete and operational Nitrogen System. Install system per manufacturer’s instructions.

A. STANDARDS

1. The nitrogen purity output of the nitrogen generator shall be at 98% or better.
2. No continuous venting of gas from the system shall be permitted; once the piping is inerted, venting to perform fill and purge breathing shall be stopped.

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3. All equipment shall be installed within the confines of the riser room – this approach reduces the leak risk associated with equipment that is installed out on the zone and facilitates easy installation and maintenance of the equipment.
4. All venting devices attached directly to the piping shall be FM Approved.
5. All air maintenance devices used as part of the nitrogen delivery piping shall be FM Approved.
6. All compressors shall comply with the NFPA 13 requirement to restore normal gas pressure to the system within 30 minutes.

B. SYSTEM MONITORING

1. The fire sprinkler contractor shall furnish and install a Pressure Switch for each sprinkler Cell Zone system. Pressure switches shall be located in the riser, within the Control Room.

C. EQUIPMENT

1. NITROGEN GENERATOR CONTROL PANEL: Locate panel in Unit A - Mech. Rm. A157. Top of panel shall be mounted on wall + 60" A.F.F. Panel requires 120 V power supply.

2. AIR COMPRESSOR: Shall be connected to the three Fire Zone Risers to maintain supervisory pressure within the fire sprinkler piping. Compressor shall be sized appropriately for the application and capable of achieving system pressure within 30 minutes in accordance with the requirements of NFPA 13, Standard for the Installation of Sprinkler Systems. When the compressor is serving more than a single riser room, a larger capacity compressor may be required.

1. Air compressor shall be a 1.0 HP 2-stage, oiless splash lubricated reciprocating compressor with an on-board after cooler and rated by the manufacturer for continuous duty service.
2. The air compressor shall have a dedicated un-switched power source sized as directed by the design engineer. The power source must be coordinated with the available power supply (as required by the air compressor manufacturer).

3. Each compressor power source shall include a service disconnect installed adjacent to the air compressor.
4. Air compressor shall have an output pressure rating of at least 100 psig.
5. Air compressor shall be capable of producing a continuous volume of compressed air that is sufficient to meet the design requirements of the fire protection system and the Nitrogen Generator.
6. Air compressor shall be equipped with an air receiver tank and shall be equipped with an automatic blow down device that empties condensate from the air receiver tank. This water discharge shall be piped to a floor drain or building exterior per local requirements. Tank volume shal be determined by the contractor.
7. Air compressor shall be connected to the Nitrogen Generator Panel with minimum 1/2 in. diameter black steel or galvanized piping.

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PART 3 - EXECUTION

3.1 GENERAL

A. Cooperate with other trades to ensure adequate space for equipment and piping placement.

B. Review plans, specifications, and shop drawings of other trades to coordinate work.

C. Install in strict accordance with approved shop drawings.

D. Install all piping, valves, and connections from mains to building fire protection systems.

E. Do not begin installation until all Agency approvals are submitted to A/E.

3.2 INSTALLATION OF PIPING, VALVES, AND ACCESSORIES

A. Install sprinkler piping to comply with applicable Codes and Standards.
   1. Offset, crossover and otherwise route piping to install system in available space.
   2. Pitch all branch lines, cross mains, feed mains and risers to drainage points.
   3. Provide angle drain valves at all low points.
   4. Plugs permitted at offsets when approved by local authority.
   5. Coordinate pipe routing with other trades prior to fabrication or installation.

B. Provide OS&Y or butterfly valve and flow switch within sprinkler system at each of following locations:
   1. Each zone takeoff within sprinkler piping system.
   2. Base of all sprinkler risers.

C. Install tamper switch on each OS&Y or butterfly valve within system, including sprinkler control, sprinkler zone, and isolation valves and post indicator valve.

D. Provide auto ball drip valves at outside fire department connections between hose connection and check and shut-off valve.

E. Flush outside fire water mains prior to connecting to inside system with a minimum water flow achieving 10 ft/sec. flow. Complete underground test certificate per NFPA 13 - 2010 edition.

F. Provide valve boxes at each outside (underground) valve.

G. Install pressure gages at top of each sprinkler risers and elsewhere as required by local authority.

3.3 SPRINKLER INSTALLATION

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A. Install in accordance with approved Shop Drawings. Modifications to system design or arrangement after approval of Drawings by local authority, may only be made after receiving written approval of authority and A/E. Such modifications do not include minor relocations in piping or head placement. Make all revisions in accordance with NFPA 13.

B. Install drain valves at low points of all piping to permit complete drainage of system without disconnection of any piping.

C. Extend main drain(s) and inspector's tests connections on ends of sprinkler branches to nearest floor drain, janitor's sink, or exterior of building. Label valves and outlets.

D. Provide chrome plated escutcheon plates at pipe penetrations of ceilings, floors, and walls.

E. Provide Firestop penetrations in accordance with Division 21.

F. Do not install sprinkler heads through or with escutcheon cover/plate covering suspended ceiling grids.

G. Locate heads centered in ceiling tile and in center of metal strip in linear metal ceilings, if such location makes added heads necessary, provide all added heads as required to meet code.

H. Relocate heads if necessary to coordinate with ceiling layout.

I. Install sprinkler heads to provide and maintain minimum 18-inch clear between bottom of deflector and top of storage, files, shelving and cabinets.

J. Install sprinklers below all obstructions including ductwork and walkways that are over 48” in width. Note: Contractor shall verify status of all variances that have been submitted prior to his bid.

3.4 ELECTRICAL WIRING

A. Electrical Contractor to provide: Supervised wiring from main waterflow indicator to outside alarm bell and fire alarm panel. Supervised wiring from sprinkler flow switches to fire alarm panel. Supervised wiring from valve tamper switches to fire alarm panel.

B. Fire Protection Contractor to be responsible for: Wiring diagrams for all devices. All other wiring not specified to provide an operating system

3.5 FIELD QUALITY CONTROL

A. Upon completion of sprinkler system installation, the Contractor is to test the entire system per NFPA 13 requirements. Contractor is to notify the authority having jurisdiction and the Owner's representative of time and date system testing will be performed so that tests can be witnessed by same. Contractor to complete the "Contractor's Material and Test Certificate" and have signed by the authority having jurisdiction, Owner's representative, and Contractor who witnessed the testing. Copies

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are to be made of the Certificate and distributed to the approving authority and Owner's representative.

B. Test sprinkler piping, including outside supplies, under hydrostatic pressure to 200 psi for 2 hours. Prove system tight to satisfaction of A/E. Inside piping to show no leakage. Leakage in underground piping in accordance with NFPA 24.

C. Test complete alarm system including control and signal circuits wired by Electrical Contractor. Coordinate with electrical. Complete testing prior to acceptance by Owner.

D. Give advance notice and arrange for field tests and inspections by local authority.

E. Flushing and sterilization of fire system water lines to be as required by NFPA 13.

F. Provide flow information for fire protection system including static pressure, residual pressure, and flow volumes. Tests to be conducted during high usage time of day.

3.6 PAINTING

A. Refer to Division 09 Section “Interior Painting”.

END OF SECTION 21 13 13

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SECTION 21 22 00

CLEAN AGENT EXTINGUISHING SYSTEMS

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. Provide a complete FM-200 fire suppression system for Security Electronics Room # A149 as indicated on the Drawings and specified herein, including all devices required to automatically detect and extinguish fires within the protected areas.

B. An inert gas protection system suppress fire by lowering the oxygen in the space to below that required for combustion. While an inert gas systems will reduce the oxygen in a space to about 15 percent, which is below the level a fire needs to burn, there is still enough oxygen in the air for people to breathe.

1.3 JOB CONDITIONS

A. Agent Contractor shall verify the exact room dimensions, elevations and volume of this work. Coordinate with the work of other trades prior to fabrication and installation. Provide additional offsets and section of piping as required to meet job conditions. Coordinate with and review all related drawings of all trades prior to start of work.

B. The Clean Agent System shall be a total flooding FM 200 extinguishing system designed to provide a uniform concentration of 7% minimum of FM 200. The amount of FM to be provided shall be the amount required to obtain the minimum uniform concentration of 10 minutes. The contractor shall take into consideration such factors as un-closable openings (if any), run-down time of fans, time required for dampers to close (and requirements for any additional dampers), and any other feature of the facility that could affect the FM concentration.

1.4 QUALITY ASSURANCE

A. Codes and Standards
   1. National Fire Protection Assoc. (NFPA) Standards
      a. No. 2001: Clean Agent Fire Extinguishing Systems.
      b. No. 70: National Electrical Code.
      c. No. 72: National Fire Alarm Code.

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d. No. 75: Standard for the Protection of Electronic Computer/Data Processing Equipment.

2. Underwriters' Laboratories, Inc. (UL) Publications and Standards
   a. Fire Protection Equipment Directory (Latest Issue with Quarterly Supplements).
   b. UL 268 Smoke Detectors for Fire Protection Signaling Systems (June 9, 1981, 2nd Ed., Rev. thru Nov. 23, 1981).
   c. UL 555 Fire Dampers and Ceiling Dampers (May 14, 1979; Errata June 1, 1979).
   d. UL 864 Control Units and Accessories for Fire Alarm Systems.
3. Extinguisher Rules and Articles 5.43-3, State Code.
4. State and Owner's Insurance Regulations and Requirements.
5. State and Local Fire Marshal Requirements.

1.5 GENERAL

A. Qualifications of installer/contractor:
   1. The system shall be installed by an experienced firm regularly engaged in the installation of automatic FM-200 fire extinguishing systems in strict accordance with NFPA standards.
   2. The contractor shall have a Nicet level III or above on staff to be the project manager directly in charge of all aspects of this project.
   3. The contractor's firm must have a minimum 10 years experience in design, installation, and testing fire suppression systems. A list of systems of similar nature and scope shall be provided at the time of proposal.
   4. The contractor shall show proof of the following prior to time of bidding:
   5. The installing Contractor shall provide certification of his capability to recharge the largest FM-200 system within 24 hours after discharge. Certification shall include information as to amount of contractor's FM-200 storage available.
   6. The installation Contractor shall be an authorized stocking distributor of the manufacturer for the equipment included in the system so that immediate replacement parts can be made from inventory. Contractor shall show proof of available telephone communications on a twenty-four hour, seven-days-a-week basis; his service personnel shall be available for emergency service at all times.

1.6 SUBMITTALS

A. The following shall be submitted for approval prior to the start of installation:
   1. Shop Drawings, Submittals, and Component Details: Manufacturer's certificate of acceptance of the qualifications of the installing contractor to install, test, maintain, and recharge the manufacturer's equipment. Shop drawing shall indicate locations, installation details, and operation details of all equipment associated with the FM-200 system. Floor plans showing equipment locations, piping, and other details, as required, be provided. Floor plans shall be drawn to a scale of not less than 1/8" = 1'-

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0". Elevations, cross section, and other details shall be drawn to a larger scale as required. Sequences of operation, electrical schematics, and connection diagrams shall be provided to completely describe the operation of the FM-200 system controls. The contractor shall illustrate the agent distribution system and provide calculations to demonstrate the volumetric concentrations.

1.7 WARRANTY

A. All FM-200 system components shall be guaranteed against defective design, materials and workmanship for one year from the date of Substantial Completion. Upon receipt of notice from the Owner of failure of any component during guarantee period, repair the system promptly with new parts at no cost to the Owner. Warranty shall include a minimum of two (2) inspections at six-month intervals as described in the UL Manual and NFPA 2001.

PART 2 - PRODUCTS

2.1 GENERAL

A. System shall be furnished and installed by a State Certified Design-Build Contractor and all components shall be the product of a single manufacturer, with name and serial number attached to each component.

Systems as manufactured by FIKE FIRE SUPPRESSION, FENWAL, ANSUL, or TYCO-SIMPLEX GRINNELL.

B. Materials and equipment shall be standard products of the manufacturer's latest design and suitable to perform the functions intended. Where two or more pieces of equipment must perform the same functions, they shall be duplicates produced by one manufacturer. The name of the manufacturer and the serial numbers shall appear on all major components. Locks for all cabinets shall be keyed alike. Equipment added to an existing system shall function in the same manner as similar components of the existing system.

C. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial and/or industrial use for 2 years prior to award date. The two-year use shall include applications of equipment and materials under similar circumstances and of similar size.

D. The 2 years of experience must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market.

E. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

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F. The equipment items shall be supported by a service organization which is a stocking distributor of the manufacturer and shall be capable of responding within 4 hours of notification for the equipment installed. The Contractor shall submit certified proof of the organization's function as a permanent service organization including its address and qualifications. Service must be performed by factory-certified technicians, who are permanent employees of the service organization qualified to service the equipment on a regular and emergency basis during the warranty period of the contract.

G. All equipment shall perform as parts of a single system. The system design shall conform to all standards as described in NFPA 2001.

H. These standards shall be used as minimum design standards. Also to be considered are the requirements of state and local authorities having jurisdiction, as well as those of the Owner's insurance carrier and good engineering practices.

2.2 SYSTEM DESCRIPTION AND OPERATION

A. The system shall be total flooding FM-200 extinguishing system designed to provide a uniform concentration of 7% minimum of FM-200. The amount of FM-200 to be provided shall be the amount required to obtain the minimum uniform concentration of 10 minutes. The contractor shall take into consideration such factors as unclosable openings (if any), run-down time of fans, time required for dampers to close (and requirements for any additional dampers), and any other feature of the facility that could affect concentration.

B. The system shall be actuated by a combination of ionization and photoelectric smoke detectors. Automatic operation in each separate protected area shall be as follows:
   1. Actuation of one (1) detector in either loop shall: Indicate on the alpha numeric display the affected detector. Energize a pre-alarm audible and visual signal associated with that area in which the detector was operated. Actuate door closer/holders on access doors to the protected area. Transmit an alarm signal to the building's fire alarm system, through a N.O. set of contacts.
   2. Actuation of a second detector in the same area shall: Indicate on the alpha numeric display the affected detector. Energize an evacuation audible and visual signal associated with the area in which the detector was operated. Start time-delay sequence. Shut down ventilation system and/or close dampers.
   3. Discharge of the FM-200 shall occur at the end of time-delay period. Upon discharge of FM-200, all power to high-voltage equipment shall be interrupted. Transmit a discharge alarm to the building fire alarm through a N.O. set of contacts. Transmit a trouble alarm to the building fire alarm through a N.O. set of contacts. Provide a N.C. set of contacts to work in conjunction with the room emergency power off switch.

C. The system shall be capable of being actuated by addressable manual discharge switches located at each exit. Operation of manual switch shall duplicate the

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cross-zones sequence description above, except that time-delay shall be bypassed.

D. Provide a remote abort switch with countdown timer and remote key operated reset switch. The abort switch shall only stop the countdown upon actuation. If released, the countdown timer will reset to the original countdown set point and the countdown will begin again. Reset will reset the switch. Activating the abort switch will not inhibit the transmission of information to the fire alarm system.

2.3 MATERIALS AND EQUIPMENT

A. General Requirements: Materials and equipment shall be standard products of the manufacturer's latest design and suitable to perform the functions intended. When one or more pieces of equipment must perform the same functions, they shall be duplicates, produced by one manufacturer. The name of the manufacturer and the serial numbers shall appear on all major components. Locks for all cabinets shall be keyed alike.

B. All devices and equipment shall be tested for compatibility with each other by UL listed and/or FM approved.

C. The system control panel shall perform the functions necessary to operate the detection and the FM-200 Suppression System. The control unit shall be approved by Underwriters' Laboratories, Inc., and/or Factory Mutual as FM-200 system control units. This control unit shall be located as shown on plans.

D. Control panel to be equipped with a 24-hour battery backup.

E. Addressable manual pull stations shall be of the dual-action type, which will require that an outer door be lifted to expose the actuation door. The concealed release switch shall be double action DPDT. The front shall be marked with the legend "FM-200 RELEASE." Push type manual pull stations shall not be permitted. Manual actuation shall bypass the delay and abort functions and shall cause all alarm and shutdown devices to operate the same as if the system had operated automatically.

F. The detectors shall be spaced, located, etc., in accordance with the manufacturer's specifications and within the guidelines of NFPA Standard 72.
   1. Photoelectronic Analog Detector: Photoelectronic detector shall be individually addressable from the control unit or remote location to permit: Setting of alarm and pre-alarm levels, readout of real time smoke input levels and control of drift and drift compensation. Detector shall provide non-polarized connection to field wiring using screw terminals. Alarm test of detector initiated at control unit shall be true test of detector optics and electronics and shall precisely duplicate in-place test, if using calibrated meter. Status indicating LED shall change state as follows:
      a. Normal Supervisory - 10 second blink

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b. Alarm - 2 second blink
c. Trouble - OFF

2. Ionization Analog Detector: Ionization detector shall functionally duplicate: level settings, read-out, line connection and LED functions of photoelectronic detector. Level setting shall comply with ionization detector requirements. Alarm test initiated at control unit shall change voltage level within dual ionization chamber to accurately test chamber and electronics. Ionization and photoelectronic detectors shall be interchangeably mounted into a common twist lock base. Control unit shall recognize change of detector type and provide proper indication that reprogram for affected address is required.

G. Alarm signals shall be operated from the control unit. The alarm bells shall be FENWAL P/N 29-116623-014, or equal in quality, performance, and features. The alarm horns shall be FENWAL P/N 29-117265-001, or equal in quality, performance, and features as specified herein. Two (2) visual alarm units shall be FENWAL P/N 75-00002-005 or equal vertical strobe unit in quality, performance and features.

H. All wiring shall be furnished and installed by the contractor. All wiring shall be installed in electrical metallic tubing (EMT) or conduit. All system components shall be securely fastened to their support independent of the wiring. Runs of conduit and wiring shall be straight, neatly arranged, properly supported, and parallel and perpendicular to walls and partitions. The sizes of the conductors shall be those specified by the manufacturer. Color code shall be used where specified. All wires shall be tagged at all junction points and shall be free from grounds and crosses between conductors. Final connections between equipment and the system wiring shall be made under direct supervision of a factory-trained representative. All wiring shall be installed to conform to the requirements of the National Electrical Code, Article 725 for class 1 Signal Systems, except as otherwise permitted for limited energy circuits, as described in NFPA 72. All wiring shall also meet State and local codes. The complete electrical installation of the system and all components shall be grounded in accordance with the National Electrical Code.

I. (Optional) Auxiliary Panels: A Graphic Annunciator will be mounted adjacent to the FN6000 System control panel. The graphic annunciator shall show a scale layout of the protected area and have indicator lamps to pinpoint the location of each concealed product of combustion detector. Only the first detector in each circuit shall indicate on the panel when alarmed. The panel shall have a push-to-test lamp switch located on the panel face.

J. Addressable abort stations shall be of the "Dead Man" type and located next to each manual station. The abort stations shall be supervised and shall indicate a trouble condition at the FM-200 control unit if depressed. "Locking" or "keyed" abort stations shall not be permitted.

2.4 FM-200 STORAGE AND DISTRIBUTION

A. Each protected area shall have its own separate supply of FM-200. The system shall be of modular design.

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1. Each supply shall be located within the hazard area or as near to it as possible so that a minimum of distribution piping is used.
2. The FM-200 shall be stored in wall/floor mounted containers. Containers should be super-pressurized with dry nitrogen to 360 PSIG at 70 deg F. Containers valves shall be burst disc and actuated by initiators. Each agent storage container shall also have a pressure gauge and pressure switch to facilitate visual and electrical supervision of the container pressure. The pressure switch shall be isolated from the container assembly by check valves such that it may be replaced without having to remove the agent from the container. Each container shall have a pressure relief device that automatically operates when internal pressure exceeds 805 PSIG. It shall be possible to determine the agent liquid level within each container without removing the storage container from its mounting bracket, disconnecting the distribution piping, or shutting down the FM-200 system.
3. Each agent storage container shall be securely mounted to a rigid surface. The bracket anchors and mounting surface shall withstand a thrust at 1000 lbs. for 5 seconds.

B. Discharge nozzles shall distribute the FM-200 throughout the protected area. The nozzles shall be FENWAL or equal in quality/function and construction and designed to provide proper distribution and weight of the agent. Ceiling penetrations shall be finished with escutcheons. All nozzles shall be brass.

C. All distribution piping shall be in accordance with the latest requirements listed in NFPA Standard 2001. All pipe length must be reamed, blown clear, and swabbed with suitable solvents to remove burrs, mill varnish, and cutting oil before assembly. For threaded fittings, Teflon tape only shall be used and applied to male pipe threads only.

PART 3 - EXECUTION

3.1 SYSTEM INSPECTION AND CHECKOUT

A. After the installation is complete, the system shall be inspected by factory-trained personnel in accordance with the manufacturer's recommended procedures.

B. All wiring shall be tested for proper connection, continuity, and resistance to ground.

C. The complete system shall be functionally tested in the presence of the Owners, and all functions, including system and equipment interlocks, must be operational at least five (5) days prior to the final acceptance test. Each detector shall be tested in accordance with the manufacturer's recommended procedures. The system and equipment interlocks, such as door releases, audible and visual alarms, and equipment shut-downs shall function at that time. Each circuit shall be tested for trouble by inducing a trouble condition to the system.

3.2 TRAINING REQUIREMENTS

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A. Prior to final acceptance, the contractor shall provide operation training to each shift of the Owner's personnel. Each training session shall include emergency procedures, abort functions, system control panel operation, trouble procedures, and safety requirements. Each session shall include a complete demonstration of the system.

3.3 OPERATION AND MAINTENANCE

A. Prior to final acceptance, the contractor shall provide complete operation and maintenance instruction manuals (two copies for each system) to the owner. All aspects of system operation and maintenance shall be detailed, including electrical schematics of all circuits, a written description of the system design, drawing illustrating control logic and equipment used in the system. Checklists and procedures for emergency situations, troubleshooting techniques, and maintenance operations shall be included.

3.4 AS-BUILT DRAWINGS

A. Upon completion of each system, the contractor shall provide two copies of as-built drawings showing actual installation details, all equipment locations (manual stations, abort switches, alarms, detectors, control panels) shall be shown, as well as exact piping routing details and agent storage positions. All facilities modifications, including door and damper installations, and modifications to insure required soak times, shall be illustrated.

3.5 ACCEPTANCE TESTS

A. Tests shall demonstrate the entire control system functions as intended. All circuits shall be tested: Automatic actuation, manual actuation, equipment shut-down, alarm devices, and storage container pressure. In addition, supervision of each circuit shall be tested.

B. A room pressurization test shall be conducted in each room to determine the presence of openings which could affect the FM-200 system concentration levels. This test will be conducted using Door-Fan system, or equivalent, with integrated computer program. All testing shall be in accordance with NFPA 2001.

C. If the room-pressurization test indicates that there are openings which could result in leakage of the extinguishing agent, the FM-200 contractor will direct the general contractor to properly seal the space and will inspect the work.

D. Upon acceptance by owners, the complete system shall be placed in operation within a nominal 24-hour period. The contractor shall provide written certification that all containers are filled as required.

3.6 FM-200 SYSTEM INSPECTIONS

A. The contractor shall provide two (2) inspections of each system under this contract during the one-year warranty period. The first inspection shall be at the six month interval after system acceptance, and the second at the 12 month

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interval. Inspections shall include determination of agent container weight and pressure and that the system is in proper working order.

B. Inspection shall also include a complete checkout of the control and alarm system. Documents certifying satisfactory system conditions shall be submitted to the Owner's technical representative upon completion of each inspection. All inspections shall be done in accordance with NFPA 2001.

C. NFPA 2001 requires the room enclosure to be inspected at least once a year, unless the owner has a documented administrative control program that addresses barrier integrity.

3.7 WARRANTY

A. All FM-200 system components furnished under this contract shall be guaranteed against defective design, materials, and workmanship for the full warranty time which is standard with the manufacturer, but in no case less than ONE (1) YEAR from the date of system acceptance.

3.8 ROOM INTEGRITY

A. The following described work is provided by other trades and not in the scope of the clean agent systems contractor. It is the responsibility of the clean agent systems contractor to coordinate his work to insure these listed items have all been addressed before the room integrity test is performed.

1. All doors must have a threshold and sweep installed and weather stripping installed around the door jam.
2. Egress doors should swing out of the protected space.
3. Door closures installed, otherwise doors should be installed with electromagnetic hold-open devices that release prior to agent discharge.
4. All windows and wall joints must be fire caulked and sealed.
5. Porous concrete block walls must be sealed.
6. Ceilings: Lay-In ceilings tiles shall be clipped and secured to grid. Seal ceiling grid shall be caulked at wall.
7. Any penetration of the room walls, ceilings and floor shall be sealed, including all conduit, cable trays outlets, switches, piping and ductwork.
8. All floor drains shall have a temporary cover.
9. All HVAC ductwork, grilles and registers are capable of capable of being air-tight prior to discharge of agent.

END OF SECTION 21 2200

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SECTION 22 05 01

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

B. INDIANA CODES

1. General Administration Rules: Amended 12/01/2014
2. Building Code: Effective 12/01/2014
3. Fire Code: Effective 12/01/2014
4. Plumbing Code: Effective 12/24/2012
5. Electrical Code: Effective 08/26/2009
6. Mechanical Code: Effective 12/01/2014
7. Handicapped Accessibility Code: 2014
8. Energy Code: Effective 05/07/2010
9. Elevator Safety Code: 2011:
11. Fuel Gas Code: Effective 12/01/2014

1.2 GUARANTEE

A. In entering into a contract covering this work, the Contractor accepts the Specifications and Drawings and guarantees that the work will be carried out in accordance with the requirements of the Specifications and Drawings or such authorized modifications as may be made in the Contract Documents. Contractor further guarantees that the workmanship and material will be first class and that only experienced workers, familiar with each particular class of work, will be employed. Contractor further guarantees to replace and make good at their own expense any defects due to faulty workmanship or material which may develop within one (1) year after final payment and acceptance by the Owner, upon receipt of written notification of defect from the Owner.

1.3 QUALITY ASSURANCE

A. Regulations and Standards: All equipment, apparatus, and systems are to be fabricated and installed in complete accordance with fire and insurance rules and regulations, the Life Safety Code, and the latest edition or revision of the following applicable regulations, standards, and codes:
1. AIA American Institute of Architects
2. ASME American Society of Mechanical Engineers
3. ASTM American Society for Testing and Materials

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4. NFPA National Fire Protection Association
5. NEC National Electric Code
6. OSHA Occupational Safety and Health Administration
7. UL Underwriter's Laboratories, Inc.
8. MCAA Mechanical Contractors Association of America, Inc.
9. ANSI American National Standard Institute
10. AWWA American Water Works Association
11. AGA American Natural Gas Association
12. PDI Plumbing and Drainage Institute
13. NACE National Association of Corrosion Engineers
14. State and Local Inspection Authorities
15. Division 01 Sections “Regulatory Requirements: and “Reference Standards” of the Project Specifications
16. References on the Drawings or in the Specifications to "code" or "building code" not otherwise identified shall mean the specific codes applicable to this Project location, together with all additions, amendments, changes, and interpretations adopted by code authorities having jurisdiction over this Project.
17. The applicable edition of all codes shall be that adopted at the time of issuance of permits by the authorities having jurisdiction, and shall include all modifications and additions adopted by that jurisdiction.
18. Give all required notices so as to comply with, and meet, all inspections required by Federal, State, and Local authorities.
19. It is not the intent herewith to modify, reduce, or change any rules, standards, regulations, or requirements that are applicable under local, state and federal codes, ordinances, or regulations of the various authorities having jurisdiction. Where the standards differ among the various authorities, the most restrictive shall apply. Where the requirements shown on the Drawings or called for in the Specifications exceed code requirements, these Drawings and Specifications shall take precedence. Where the requirements within the specifications of this division of work and the Drawings conflict with the referenced Divisions, Sections, and other documents, the documents having the most restrictive and the higher cost requirements shall apply.

1.4 JOB CONDITIONS AND COORDINATION

A. Local Conditions
1. Each Trade Contractor is to inform himself of the conditions under which the work is to be performed, the site of the work, the structure of the ground, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work to be done.
2. Utility Coordination: Contractors shall contact, coordinate, and review indicated utility data with the local utility companies. Verify existing utility locations, verify new pipe tap locations and piping routes with the utility.
   a. Water: Contractor to verify water meter and backflow requirements.
   b. Gas: Contractor to verify meter requirements.
   c. Sewer: Contractor to verify all proposed sewer connection points.

B. Present Job Site Inspection

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1. Each contractor shall schedule through the Construction Manager a visit to the present site proposed for the work before presenting a Bid and shall make a careful inspection of the existing conditions.
2. During the site visit, each Trade Contractor is to investigate for any existing conditions and responsibilities which are not clearly defined by the Drawings and Specifications. If any such conditions exist, they shall bring them to the attention of the A/E in writing. The A/E will then make the required written clarification. The absence of questions before the opening of bids shall indicate a clear understanding of the scope of work and the Contractor's responsibility.

C. Concrete Housekeeping Pads and Supporting Foundations
1. Unless otherwise specified or noted on the Drawings, the Concrete Contractor is to provide concrete pads and foundations as indicated on the Drawings for all mechanical equipment.
2. Unless otherwise specified or noted on the Drawings, the Contractor or Subcontractor whose equipment the concrete pad or foundation services is to locate, size, and pay the Concrete Contractor to provide concrete pads and foundations as indicated on the Drawings for all of their equipment.
3. Concrete pads as may be indicated are based upon the design and layout-based manufacturer and model of equipment and devices as specified or as scheduled or noted on the Drawings.
4. The individual Trade Contractor furnishing the equipment or devices is to verify and coordinate all concrete pad sizes so as to have same of proper size to serve the equipment or device supplied and verify the position of all anchor bolts.
5. Any additional cost for larger than indicated pad or foundation sizes to fit the approved manufacturer and model of the equipment or devices is to be borne by the Trade Contractor who supplies such equipment or devices.
6. Concrete equipment pads shall extend a minimum of 6” beyond the equipment of product mounted thereon.
7. Contractor shall verify equipment pad size and locations with nearby floor drain locations.

D. Permits and Fees: This Contractor is to obtain all permits and pay all fees required for the work under Division 22 of the Work.

E. Royalties and Patents
1. The Trade Contractor is to pay all royalties and license fees. They shall defend, indemnify, and hold the Owner and A/E harmless from any and all suits, demands or claims for infringement of any patent rights.
2. The review by A/E or Owner of any method of construction, invention, appliance, process, article, device or material of any kind is to be for adequacy of work, and is not to be construed as an approval of the use thereof by the Contractor in violation of any patent or other rights of any third person.

F. Wiring and Conduit Requirements: In general, most wiring and conduit requirements are addressed, either upon the Drawings as a part of a packaged equipment assembly specifications, or within Divisions 26, 27 and 28 of the Specifications. However, should an equipment component, panel, or system device need additional wiring and conduit so as to be complete, approved and fully operational, the Contractor who supplied the equipment component, panel or system device shall be responsible for the

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required wiring and conduit as well as circuit disconnect and protection for same when it is not otherwise covered by the Project Drawings and Specifications.

G. Coordination: Coordinate the exact location of this work with the work of other trades prior to fabrication or installation of same. Verify all dimensions and elevations. Provide additional offsets and sections of material as may be required to meet the applicable job condition requirements. Coordinate with and review all related construction Drawings and Shop Drawings of all equipment suppliers prior to start of work.

1.5 SPECIFICATIONS AND DRAWINGS

A. These specifications and Drawings are intended to describe and provide for a complete and finished project. They are intended to be complementary. All items of work called for by either shall be as binding as if called for by both. The work described shall be complete in every detail, notwithstanding the fact that every item necessarily involved is not particularly mentioned or shown. If the Bidder, Supplier or Contractor sees anything to question, it must be brought to the attention of the A/E immediately.

B. Minor Deviations: The Drawings accompanying these Specifications indicate the general design and arrangement of equipment, apparatus, fixtures, accessories and piping necessary to complete the installation of the system. The exact location or arrangement of the apparatus and equipment, unless otherwise dimensioned, is subject to minor changes necessitated by field conditions and shall be required without additional cost to the Owner. Measurements shall be verified through actual observation at the construction site. Each Trade Contractor shall be responsible for fitting all of their work into place in a satisfactory and workmanlike manner, to the approval of the A/E and Owner.

C. Provide all labor and materials necessary for the completion of the work described. Referenced codes and industry standards and methods shall apply when no other specifics are indicated. Bring questions relating to this paragraph to the attention of the A/E for resolution prior to the receipt of Bids.

D. All Work indicated on Drawings, diagrams, or details in part only are to continue throughout unless distinctly marked otherwise. The same applies to other parts of the project where merely a typical reference plan, diagram, or section of the drawing is complete. The balance is intended to be the same as the typical plan, section, or diagram as shown and is to be figured accordingly.

E. The specifications are divided into trades and divisions only for the distinct purpose of facilitating the work. However, the Trade Contractor will become responsible for furnishing all labor and materials necessary to complete the project as contemplated by the Drawings and Specifications. Any item mentioned under any heading of the Specifications must be supplied even though it is not called for again under the heading for the respective work.

F. Should discrepancies occur within the Contract Documents, the more stringent and more costly approach shall apply for bidding purposes. The Contractor is to notify the A/E of discrepancies for clarification. Clarifications issued after the Contract is

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awarded shall be incorporated by the Contractor at no additional costs and shall be reviewed by the A/E to determine if a reduction in cost is justified.

1.6 TRADE CONTRACTORS, SUBCONTRACTORS AND SUPPLIERS

A. The Trade Contractor is any person or organization who contracts to perform work for the Project. Wherever the word "Contractor" is used on the Drawings or in the Specifications, it shall be construed to mean the Trade Contractor applicable to the Title Division of these specifications.

B. A Sub-Contractor is a person or organization who has a direct contract with a Trade Contractor to perform any of the Work at the site and includes all who furnish material worked to a special design in accordance with the Drawings and Specifications, but excludes suppliers or persons furnishing material not specially designed. Wherever the term "Sub-Contractor" is encountered in the Contract Documents, it shall mean the Sub-Contractor and/or their Sub-Sub-Contractors and/or their Material Suppliers.

C. A Sub-Sub-Contractor is a person or organization who has a direct or indirect contract with a Sub-Contractor to perform any of the Work at the project site or for the subject project.

D. A Material Supplier is a person or organization who has a direct contract with a Trade Contractor to furnish material not specially designed.

E. It shall be the responsibility of each Trade Contractor to be fully familiar with various local trade jurisdictional requirements and to engage the services of any other Sub-Contractors as may be required within the various trades to complete all of the work as indicated upon the Drawings and within the Specifications under their respective division or section. Only Trade Sub-Contractors with established knowledge and skills of their specific trade shall be used, so that all work is performed in a complete, finished, and professional manner.

F. Whenever any provisions of the Specifications conflict with any agreements or regulations in force among members of any Trade Associations, Unions, or Councils which regulate or distinguish what work shall or shall not be included in the work of any particular trade, the Trade Contractor shall make all necessary efforts to reconcile any such conflict without delay, damage or cost to the Owner.

G. If the progress of the work is affected by any undue delay in furnishing or installing any items of material or equipment required under the contract because of a conflict involving any such agreement or regulation, the A/E may require that other material or equipment of equal kind and quality be provided at no additional cost to the Owner.

H. Any Trade Contractor, subcontractor, or material supplier not normally employing union labor shall make all provisions necessary to avoid any resulting disputes with labor unions and shall be responsible for any delays, damages or extra cost caused by employment of such non-union labor, except as otherwise governable by state or federal rules and regulations.

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I. Each Trade Contractor shall pay for all applicable Federal, State and local taxes on all materials, labor or services furnished by him, and all taxes arising out of their operations under the Contract Documents which may be imposed upon or collectable from the Owner or become a lien against their property. Such taxes shall include, but not be limited to, Occupational, Sales, Use, Excise, Social Security and Unemployment Taxes, customs duties, and all income taxes and other taxes now in force or enacted prior to final acceptance of the work. The Trade Contractor shall assume all liability for the payment of and shall pay any unemployment benefits payable under any Federal or State law to individuals employed by him during the progress of the work covered by the Contract.

J. It is the responsibility of each Trade Contractor to coordinate the various related equipment requirements between their subcontractors, suppliers, and other trade contractors, and to also follow the approved manufacturer's installation instructions.

1.7 OPERATIONAL AND MAINTENANCE INSTRUCTIONS

A. All operational and maintenance instructions that are provided to various Owner-selected members of the facility engineering and/or maintenance staff are, at the same time presented, to be fully recorded on DVD by the Contractor so that all such sessions can be later reviewed by the Owner's staff on a retraining basis as needed. All such DVDs are to become the property of the Owner at the end of each applicable training period, with one copy of each also being supplied to the A/E for the A/E project files.

PART 2 - PRODUCTS

2.1 MANUFACTURERS/PRODUCTS/SUBMITTALS

A. Under the Base Bid, no other manufacturers except those indicated on the Drawings or those listed within the Sections of this Division, that are, in turn, able to comply with the contract document requirements and minimum standards of these specifications, will be acceptable. In addition to specific required "Alternates," proposed substitutions that may or may not be acceptable to the Owner may be submitted by the Contractor only at the time of initial base bid submittal.

B. Although design-based models of various manufacturers may be indicated within the various schedules, it is the responsibility of the various equipment manufacturers to verify the model selections so that all items of equipment comply with the minimum standards of performance that are indicated within the schedules, as well as the requirements within various sections of the specifications under which the equipment is also specified.

C. All submittals shall conform completely to the requirements of the Contract Documents, including all requirements set forth in Division 01 Section “Submittals”.

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D. Shop Drawings are to be submitted on each item of specified or scheduled equipment, valves, specialties, insulation, fixtures, drains, controls and related accessories. All control submittals must include a typed sequence of control for each system.

2.2 ACCESS DOORS AND PANELS

A. Unless otherwise indicated, each Trade Contractor is to locate and furnish all access doors required for non-accessible surfaces (such as ceilings, walls, chases, and similar locations), so that all valves and similar items are easily accessible for operation, inspection and maintenance. Access doors for ceiling, walls, chases, etc. are to be installed by the General Contractor. The Trade Contractor is to bear the costs of the installation of the access doors.

B. See Section 08 3113 for access door types and specifications. The size of the access doors shall provide proper access for service, routine maintenance, removal and replacement of the product. Minimum size to be 12 inch x 12 inch, or as indicated or required to allow inspection of items served.

C. LAY-IN CEILING: Removable lay-in ceiling tiles in 2 X 2 foot or 2 X 4 foot configuration, provided under Lay-Section 09500, are sufficient to use as access panels no additional access provisions are required unless specifically indicated.

D. CONCEALED SPLINE CEILINGS: Removable sections of ceiling tile held in position with metal slats or tabs compatible with the ceiling system used will be provided under Section 09500.

E. PLASTER WALLS AND CEILINGS: 16-gauge frame with not less than a 20-gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers, and similar wet areas, concealed hinges, screwdriver operated cam latch for general applications, key lock for use in public or secured areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the item needing service; minimum size is 12" by 12"

2.3 EXCAVATION AND BACKFILL

A. See Civil Specifications for all additional requirements.

B. Perform all excavation and backfill work necessary to accomplish indicated plumbing systems installation. Excavate to bottom of pipe and structure bedding, 4" in stable soils, 6" in rock or wet trenches and 8" in unstable soil. Finish bottoms of excavations to true, level surface.

B. At no time place excavated materials where they will impede surface drainage unless such drainage is being safely rerouted away from the excavation.

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C. Excavate whatever materials are encountered as required to place at the elevations shown, all pipe, manholes, and other work. Remove debris and rubbish from excavations before placing bedding and backfill material.

D. Remove surplus excavated materials from site.

E. Verify the locations of any water, drainage, gas, sewer, electric, telephone or steam lines which may be encountered in the excavation. Underpin and support all lines. Cut off service connections encountered which are to be removed at the limits of the excavation and cap.

F. Provide and maintain all fencing, barricades, signs, warning lights, and/or other equipment necessary to keep all excavation pits and trenches and the entire subgrade area safe under all circumstances and at all times. No excavation shall be left unattended without adequate protection.

G. Elevations shown on the plans are subject to such revisions as may be necessary to fit field conditions. No adjustment in compensation will be made for adjustments up to two (2) feet above or below the grades indicated on the plans.

H. Install lines passing under foundations with minimum of 1-1/2 inch clearance to concrete and insure there is no disturbance of bearing soil.

I. Bed pipe up to a point 12" above the top of the pipe. Take care during bedding, compaction and backfill not to disturb or damage piping.

J. Mechanically compact bedding and backfill to prevent settlement. The initial compacted lift to not exceed 24" compacted to 95% density per Modified Proctor Test (ASTM D-1557). Subsequent lifts under pavements, curbs, walks and structures are not to exceed 12" and be compacted to 95% density per Modified Proctor Test. In all other areas where construction above the excavation is not anticipated within 2 years, mechanically compact backfill in lifts not exceeding 24" to 90% density per Modified Proctor Test. Route the equipment over each lift of the material so that the compaction equipment contacts all areas of the surface of the lift.

2.4 SHEETING, SHORING AND BRACING

A. Provide shoring, sheet piling and bracing in conformance with State and Local codes to prevent earth from caving or washing into the excavation. Shore and underpin to properly support adjacent or adjoining structures. Abandon in place shoring, sheet piling and underpinning below the top of the pipe, or, if approved in advance by the engineer, maintained in place until other permanent support approved by the engineer is provided.

2.5 DEWATERING

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A. See dewatering requirements in Civil specification section.

2.6 EQUIPMENT NOISE AND VIBRATION

A. Vibration from equipment shall not be apparent in occupied areas of the building, Contractor shall verify that rotating parts of the equipment is properly balanced.

B. Measured sound levels exceeding design criteria is grounds for modification as required to comply with manufacturers recommendations at no additional cost to the Owner.

2.7 BUILDING ACCESS

A. Arrange for the necessary openings in the building to allow for admittance or removal of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

2.8 EQUIPMENT ACCESS

A. Install all piping, conduit and accessories to permit access to equipment for maintenance and service. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Access doors in general construction are to be furnished by the Plumbing Contractor and installed by the General Contractor.

2.9 COORDINATION

A. Coordinate all work with other contractors prior to installation. Any work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

B. Verify that all devices are compatible for the type of construction and surfaces on which they will be used.

2.10 PIPE SLEEVES

A. Provide galvanized, schedule 40 pipe sleeves for pipe penetrations through interior and exterior walls to provide a backing for sealant or firestopping. Patch wall neatly around sleeve to match adjacent wall construction and finish. Grout area around sleeve in masonry construction. In finished spaces where pipe penetration through wall is exposed to view, sheet metal sleeve shall be installed flush with face of wall.

B. **Pipe sleeves must be installed in ALL new poured concrete construction.** Sleeves shall be schedule 40 steel pipe (sized to allow insulated pipe to run through sleeve), cast in place.

C. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building. 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

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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.

D. Prepare and paint damaged galvanized coatings and ends of sleeves with galvanizing repair paint according to ASTM A 780 and manufacturer's written instructions.

E. In all piping floor penetrations, fire rated and non-fire rated, top of sleeve shall extend 1 inch above the adjacent finished floor. In existing floor penetrations, core drill sleeve opening large enough to insert schedule 40 sleeve and grout area around sleeve with hydraulic setting, non-shrink grout. If the pipe penetrating the sleeve is supported by a pipe clamp resting on the sleeve, weld a collar or struts to the sleeve that will transfer weight to existing floor structure.

F. For floor penetrations through existing floors in mechanical and wet locations listed below, core drill opening and provide 1-1/2" x 1-1/2" x 1/8" galvanized steel angles fastened to floor surrounding the penetration or group of penetrations to prevent water from entering the penetration. Provide urethane caulk between angles and floor and fasten angles to floor a minimum of 8" on center. Seal corners water tight with urethane caulk.

G. Pipe penetrations in areas subject to public view shall have an escutcheon plate.

2.12 SPACE REQUIREMENTS FOR EQUIPMENT

A. Equipment has been selected to fit into physical space provided, while allowing room for access, servicing, removal and replacement of parts. Typically allow a minimum of 24" clear space between pieces of equipment.

B. Since space requirements and equipment arrangements vary according to manufacturer, the responsibility for apace and access requirements, is the responsibility of the installing contractor.

C. Contractor shall provide proper space and access for equipment in accordance with code requirements and the requirements of the local inspection department and the recommendations of the equipment manufacturer.

D. Contractor shall verify the size and weight limitations of the space in which it is to be installed and that doors or other building openings are adequate size to permit the entry of the equipment without alterations to the building. The cost of such alterations caused by failure to comply with these instructions shall be borne by the Contractor.

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PART 3 - EXECUTION

3.1 GENERAL

A. Provide all materials, labor, equipment, and services necessary for a complete and operable installation as specified and shown on the Drawings. The word "Provide" shall mean "Furnish and install."

B. Provide new material and equipment in strict accordance with these Specifications and the Project Drawings.

C. At all times, take such precautions as are necessary to protect materials from damage. Close all pipe openings to prevent obstructions and contamination.

3.2 CUTTING AND PATCHING IN BUILDINGS

A. Each Contractor is responsible for all costs associated with the necessary cutting and patching as required for the installation of their work, unless otherwise indicated.

B. Patching is to be performed by the trade proper for each material to be patched. Patching shall leave premises and finishes in a complete and neat condition comparable to the original. Painting of patched surfaces to be by the painting sub-contractor of the General Contractor, unless otherwise specifically indicated or the plumbing/fire protection contractor is the prime contractor for the project. Maintain the fire integrity of all walls, floors, ceilings, and partitions.

3.3 PROTECTION

A. Protect equipment and trim against damage and injury due to building materials, acid, tools, equipment and any causes incidental to construction. Cover the finished surface of each piece of equipment with building paper or similar protection. Replace all equipment damaged by any cause and any trim with marred or scratched finish at no cost to the Owner, upon receipt of written notification from the A/E.

B. Where materials to be installed are being stored at or near the project during construction, arrange such materials so as to minimize the possibility of contamination, corrosion and damage. Keep ends of pipe, equipment, and specialties properly closed during construction and installation to avoid the possibility of miscellaneous materials being placed in the openings.

3.4 PAINTING

A. See Division 09 Section “Interior Painting”.

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3.5 ADJUST AND CLEAN

A. Inspect all equipment and put in satisfactory working order.
   1. Clean all exposed and concealed items.
   2. Clean floor drains, cleanouts, and plumbing fixtures.
   3. Clean specialties.
   4. Clean all covers.
   5. Clean exposed piping.
   6. Adjust pumps, balancing valves, and faucets for proper flow rates.
   7. Adjust water heaters and thermostatic mixing valves for required temperatures.

END OF SECTION 22 05 01

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SECTION 22 05 02

SELECTIVE DEMOLITION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Demolish and remove all items required to complete the work indicated.
2. Demolish designated building equipment and fixtures.
3. Demolish designated construction.
4. Cutting and alterations for completion of the Work.
5. Protecting items designated to remain.
6. Removing demolished materials.
7. Cap and identify existing utilities.
8. Provide adequate shoring and bracing.

1.2 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Demolition Schedule: Indicate overall schedule and interruptions required for utility and building services.

C. Shop Drawings:
1. Indicate demolition and removal sequence.
2. Indicate location of items designated for reuse or Owner’s retention.
3. Indicate location and construction of temporary work.

1.3 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution Requirements: Requirements for submittals.

B. Project Record Documents: Accurately record actual locations of capped utilities, concealed utilities discovered during demolition and subsurface obstructions.

C. Operation and Maintenance Data: Submit description of system, inspection data, and parts lists.

1.4 QUALITY ASSURANCE

A. Conform to applicable code for demolition work, dust control, products requiring electrical disconnection and re-connection.

B. Conform to applicable code for procedures when hazardous or contaminated materials are discovered.

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C. Obtain required permits from authorities having jurisdiction.

1.5 PRE-INSTALLATION MEETINGS

A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.6 SCHEDULING

A. Section 01 32 16 - Network Analysis Schedules: Requirements for scheduling.

B. Schedule Work to coincide with new construction.

C. Cooperate with Owner in scheduling noisy operations and waste removal that may impact Owners operation and in adjoining spaces.

D. Perform noisy or dusty work as scheduled with the Owner.

E. Coordinate utility and building service interruptions with Owner.
   1. Do not disable or disrupt building fire or life safety systems without three days prior written notice to Owner.
   2. Schedule tie-ins to existing systems to minimize disruption.
   3. Coordinate Work to ensure fire sprinklers, fire alarms, smoke detectors, emergency lighting, exit signs and other life safety systems remain in full operation in occupied areas.

1.7 PROJECT CONDITIONS

A. Conduct demolition to minimize interference with adjacent and occupied building areas.

B. Cease operations immediately if structure appears to be in danger and notify Architect/Engineer. Do not resume operations until directed.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 PREPARATION

A. Notify affected utility companies before starting work and comply with their requirements.

B. Mark location and termination of utilities.

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C. Erect, and maintain temporary barriers and security devices, including warning signs and lights, and similar measures, for protection of the public, Owner, and existing improvements indicated to remain.

D. Erect and maintain weatherproof closures for exterior openings.

E. Erect and maintain temporary partitions to prevent spread of dust, odors, and noise to permit continued Owner occupancy.

F. Prevent movement of structure; provide temporary bracing and shoring required to ensure safety of existing structure.

G. Provide appropriate temporary signage including signage for exit or building egress.

H. Do not close or obstruct building egress path.

I. Do not disable or disrupt building fire or life safety systems without 3 days prior written notice to Owner.

3.2 SALVAGE REQUIREMENTS

A. Coordinate with Owner to identify building components and equipment required to be removed and delivered to Owner.

B. Tag components and equipment Owner designates for salvage.

C. Protect designated salvage items from demolition operations until items can be removed.

D. Carefully remove building components and equipment indicated to be salvaged.

E. Disassemble as required to permit removal from building.

F. Package small and loose parts to avoid loss.

G. Mark equipment and packaged parts to permit identification and consolidation of components of each salvaged item.

H. Prepare assembly instructions consistent with disassembled parts. Package assembly instructions in protective envelope and securely attach to each disassembled salvaged item.

I. Deliver salvaged items to Owner. Obtain signed receipt from Owner.

3.3 DEMOLITION

A. Conduct demolition to minimize interference with adjacent and occupied building areas.

B. Maintain protected egress from and access to adjacent existing buildings at all times.

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C. Do not close or obstruct roadways or sidewalks without permits.

D. Cease operations immediately when structure appears to be in danger and notify Architect/Engineer.

E. Disconnect and remove designated utilities within demolition areas.

F. Cap and identify abandoned utilities at termination points when utility is not completely removed. Annotate Record Drawings indicating location and type of service for capped utilities remaining after demolition.

G. Demolish in orderly and careful manner. Protect existing improvements and supporting structural members.

H. Carefully remove building components indicated to be reused.
   1. Disassemble components as required to permit removal.
   2. Package small and loose parts to avoid loss.
   3. Mark components and packaged parts to permit reinstallation.
   4. Store components, protected from construction operations, until reinstalled.

I. Remove demolished materials from site except where specifically noted otherwise. Do not burn or bury materials on site.

J. Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.

K. Remove temporary Work.

END OF SECTION

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SECTION 22 05 07

EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 1, General Requirements.

1.2 DESCRIPTION OF WORK

A. Each Trade Contractor is to provide all excavating, trenching, sheeting, bracing, pumping, and backfilling as required for the installation of his work.

1.3 QUALITY ASSURANCE

A. Testing
   1. All testing is to be done by an independent testing laboratory employed by this Contractor and approved by the Owner and A/E.
   2. Conduct up to 10 tests per Trade per 40,000 gross square foot of compacted surface serving each Trade's specific area of work to determine the compaction density of backfill.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Subbase Material: 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.

C. Base Course: 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.

D. 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.

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E. Bedding Course: 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-inch sieve and not more than 8 percent passing a No. 200 sieve.

F. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

G. 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.

H. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.

I. Impervious Fill: Clay gravel and sand mixture capable of compacting to a dense state.

2.2 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the 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. Yellow: Gas, oil, and dangerous materials.
   2. Blue: Water systems.
   3. Green: Sewer systems.

PART 3 - EXECUTION

3.1 GENERAL

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. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.2 DEWATERING

A. Prevent surface water and ground water from entering interior of building 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.

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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. If necessary, install a temporary submersible pump and basin to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.3 EXCAVATION, GENERAL

A. Rock 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.
   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
   2. Remove rock to lines and grades indicated to permit installation of permanent construction.
   3. Earth excavation includes excavating visible rocks on surface and below surfaces. Intermittent drilling, ram hammering or ripping of material shall be included with the contractor's project bid.
   4. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction.
   5. Pipe trench widths to provide the following clearance on each side of pipe. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe, unless otherwise indicated. Clearance: 12 inches each side of pipe.
   6. Trench Bottom Excavate trenches 6 inches deeper than bottom of pipe elevation to allow for bedding course.

3.4 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:
   1. Construction below finish grade including, where applicable, sub-drainage, damp-proofing, waterproofing, and perimeter insulation.
   2. Surveying locations of underground utilities for Record Documents.
   3. Testing and inspecting 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.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.5 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

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B. 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.

C. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings.

D. Provide 4-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.

E. Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. **Coordinate backfilling and compaction at each 6" layer**.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.6 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:
   1. Under steps and ramps, use engineered fill.
   2. Under building slabs, use engineered fill.
   3. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.7 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
   1. Do not place backfill or fill soil 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.

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3.8 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches 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 soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight:
   1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
   2. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.9 GRADING

A. General: Uniformly grade areas to a smooth surface, free of 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. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.10 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. Scarify or remove and replace soil material to depth as directed by A/E; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.11 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.

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SECTION 22 05 13

COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT MOTORS

A. Motors shall be of sufficient size for the duty to be performed and shall not exceed the motor's full-rated load when the driven equipment is operating at specified capacity under the most severe conditions likely to be encountered. Motors shall be established, U.S.-manufactured industry standard types for the service intended, having normal starting torque and low starting current characteristics, unless other characteristics are specified. When electrically driven equipment is furnished which materially differs from the contemplated design, the Contractor supplying the driving equipment shall pay for and make necessary the adjustments to the wiring, disconnect devices and branch-circuit protection to accommodate the equipment actually installed. Motors and equipment shall meet ASHRAE 90-75, and State and Local Energy Code minimum COP requirements. Provide suitable overload protection for each motor.

B. Unless otherwise specified or noted on the Drawings, motors shall be suitable for the service intended, shall be of latest industry standards of design for maximum energy efficiency, and shall be continuous-duty-type.

C. Motors less than 3/4 HP shall normally be 120-volt, 1-phase, 60-HZ.

D. Coordinate and verify voltage and phase required with Electrical Drawings, as well as equipment scheduled data.

E. It shall be the responsibility of this contractor to coordinate and verify the applicable phase and voltage requirements with the electrical contractor before submittal of Shop Drawings.

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2.2 MOTOR CONTROLLERS AND DISCONNECTS

A. Except as otherwise specified in each of the various sections of Division 22, motor controllers and disconnects shall be as specified under Divisions 26, 27 and 28.

B. Verify applicable voltage, phase, and protective device requirements with electrical contractor before manufacture or installation of equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall comply with manufacturer's latest published instructions and all applicable inspection and code authority requirements.

3.2 MOTOR EFFICIENCIES

A. Drip-Proof Motors

3600 RPM		***1800 RPM***	
HP	**NOMINAL FULL-LOAD EFFICIENCY PERCENT**	**HP**	**NOMINAL FULL-LOAD EFFICIENCY PERCENT**
1-1/2	81.0	1	84.0
2	84.0	1-1/2	84.0
3	86.0	2	84.0
5	87.0	3	88.0
7-1/2	87.0	5	88.0

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B. Totally Enclosed, Fan-Cooled Motors

3600 RPM		*1800 RPM*	
HP	**NOMINAL FULL-LOAD EFFICIENCY PERCENT**	**HP**	**NOMINAL FULL-LOAD EFFICIENCY PERCENT**
1-1/2	81.0	1	81.0
2	84.0	1-1/2	84.0
3	84.0	2	82.0
5	86.0	3	82.0
7-1/2	88.0	5	85.0

END OF SECTION 22 05 13

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SECTION 22 05 19

METERS AND GAUGES

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 SUMMARY

A. This Section the includes the following types of meters and gauges: Temperature gauges and fittings. Pressure gauges and fittings.

B. Meters and gauges furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 22 specifications.

1.3 QUALITY ASSURANCE

A. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.

B. ASME and ISA Compliance: Comply with applicable portions of ASME and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

1.4 SUBMITTALS

A. Shop Drawings: Each equipment and material item specified.

B. Product Data: Product data for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.

C. Samples: Not required for review.

D. Contract Close-Out Information: Maintenance data for each type of meter and gauge in each building for inclusion in Operating and Maintenance Manuals specified in Division 01, and Division 22. Portable test plug test kit and portable meter receipts as described in this Section.

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PART 2 - PRODUCTS

2.1 THERMOMETERS, GENERAL

A. Accuracy: Plus or minus 1% of range span or plus or minus one scale division to maximum of 1.5% of range span. Scale Range: Temperature ranges for services listed as follows: Domestic Hot Water: 30 deg to 240 deg with 2 deg scale divisions (0 deg to 115deg C with 1 deg scale divisions). Domestic Cold Water: 0 deg to 100 deg F with 2 deg scale divisions (minus 18 deg to 38 deg C with 1 deg scale divisions).

2.2 THERMOMETERS

A. Weiss Model DVU35 digital self powered, glass passivated thermistor, internal potentiometer with 6” stem. Thermometer wells to be brass or stainless steel, 2” extension in insulated piping. Provided threaded cap nut and cap.

B. Manufacturers: Weiss, Ashcroft, Jay, Trerice, Miljoco, or Marshalltown.

2.3 DIAL-TYPE INSERTION THERMOMETERS

A. Type: Bimetal stainless steel case and stem, 1-inch diameter dial, dust and leakproof, 1/8-inch diameter tapered-end stem with nominal length of 5 inches.

B. Manufacturers: Ashcroft Dresser Industries/Instrument Div., Trerice (H.O.) Co., Weiss Instruments, Inc.

2.4 THERMOMETER WELLS

A. Brass or stainless steel, pressure-rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.

B. Manufacturers: Marshalltown Instruments, Inc., Trerice (H.O.) Co., Weiss Instruments, Inc.

2.5 PRESSURE GAUGES

A. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube-type, bottom connection.

B. Case: Drawn steel or brass, glass lens, 4-1/2-inch diameter.

C. Connector: Brass, 1/4-inch NPS.

D. Scale: White coated aluminum, with permanently etched markings.

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E. Accuracy: Plus or minus 1% of range span.

F. Range: Conform to the following: Vacuum: 30 inch Hg to 15 psi, All fluids: 2 times operating pressure

G. Manufacturers: Ametek, U.S. Gauge Div., Ashcroft Dresser Industries/Instrument Div., Marsh Instrument Co., Unit of General Signal, Marshalltown Instruments, Inc., Trerice (H.O.) Co., Weiss Instruments, Inc.

2.6 PRESSURE GAUGE ACCESSORIES

A. Siphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

B. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

C. Manufacturers: Ametek, U.S. Gauge Div., Ashcroft Dresser Industries/Instrument Div., Marsh Instrument Co., Unit of General Signal, Marshalltown Instruments, Inc., Trerice (H.O.) Co., Weiss Instruments, Inc.

2.7 TEST PLUGS

A. Test plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and two self-sealing valve-type core inserts suitable for inserting a 1/8 inch O.D. probe assembly from a dial-type thermometer or pressure gauge. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range: Air, Water, Oil, and Gas, 20 deg to 200 deg F (minus 7 deg to 93 deg C): Neoprene, Air and Water, minus 30 deg to 275 deg F (minus 35 deg to 136 deg C): EPDM

C. Ranges of pressure gauge and thermometers shall be approximately two times systems operating conditions.

D. Manufacturers: MG Piping Products Co., Peterson Equipment Co., Inc., Sisco, A Spedco, Inc. Co., Trerice (H.O.) Co., Watts Regulator Co., Flow Design, Inc.

PART 3 - EXECUTION

3.1 THERMOMETER INSTALLATION

A. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

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B. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.

3.2 INSTALLATION OF PRESSURE GAUGES

A. Install pressure gauges in piping tee with pressure gauge valve, located on pipe at most legible position.

B. Pressure Gauge Needle Valves: Install in piping tee with snubber. Install siphon in lieu of snubber for steam pressure gauges.

C. Install pressure gauges on the inlet side and outlet side of all **Backflow Preventers**.

3.3 INSTALLATION OF TEST PLUGS

A. Test Plugs: Install in piping tee where indicated, located on pipe at most legible position. Secure cap. Install test plugs adjacent to each piping point where a temperature sensing device is required by control specifications.

B. Test Kit: Provide test kit consisting of one pressure gauge, gauge adapter with probe, two bimetal dial thermometers, and carrying case. Turn over to Owner at completion of job and obtain written receipt. Forward copy of receipt to A/E as part of close-out documents.

3.4 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touch-up paint.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other sections of Division 22. The drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

B. Install meters and gauges piping adjacent to machine to allow servicing and maintaining of machine.

END OF SECTION 22 05 19

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SECTION 22 05 23

GENERAL-DUTY VALVES

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 QUALITY ASSURANCE

A. Valve Bodies, Shells and Seats: Factory-tested.

B. Standard for 125 psi and 150 psi saturated steam rated valve pressure containing parts: ASTM B62.

C. Standard for 200 psi and 300 psi valves with metallic seats: ASTM B61.

D. Iron Body Valves: Pressure-Containing Parts: ASTM A126, Grade B, Face-to-Face and End-to-End Dimensions: ANSI B16.10, Design, Workmanship, Materials, Testing: MSS-SP-70, 71, Use domestically manufactured valves where required by a Buy American Plan.

E. Butterfly Valves: Face-to-Face and End-to-End Dimensions: MSS-SP-67.

F. Valve Stems: ASTM B371, Alloy C69400; ASTM B371, Alloy C65100H04 (rolled silicon brass); or other material equally resistant to dezincification.

G. Pressure Castings: Free of impregnating materials.

H. Manufacturer's name or trademark and working pressure stamped or cast into body.

1.3 SUBMITTALS

A. Shop Drawings: Schedule indicating proposed valve for each application.

B. Product Data: Manufacturer's cut sheets and/or literature, Performance data.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

E. Contract Closeout Information: Valve chart indicating valve identification number, valve type, service, manufacturer and model number, and location of valve, Operating and maintenance manuals.

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1.4 JOB CONDITIONS

A. Coordinate the exact application and location of this work with the work of other trades prior to installation within various piping systems. Verify all positions and elevations. Provide additional offsets and section of piping as required to position valves for equipment clearance and accessibility as well as system and valve operational conditions.

B. Valve manufacturer to verify indicated figure or model numbers so that selection meets required description and conditions specified. Specified data for valve shall take precedence over indicated figure or model number. Provide proper seat and seal material for applicable temperature, pressure and service indicated for each valve application.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Gate, Butterfly, Check & Ball Valves: Jomar, Nibco, Hammond, Crane, Jenkins, Milwaukee, Apollo, Mueller.

2.2 DOMESTIC WATER VALVES

A. For gauge valves within steel or copper lines of 1/8 inch or 1/4 inch size, threaded or solder, 150 psig steam or 300 psig w.o.g., union bonnet, integral seat, renewable seat and disc, bronze globe valve conforming to MSS-SP-80, ASTM B-62.

B. For service valves within steel piping of 1/4 inch through 2 inch size; two-piece ball valve with bronze solder ends, lever handle, stainless steel ball and stem, Class 150 SWP-600 w.o.g.

C. For service valves in copper piping 2-1/2 inch through 4 inch size; 200 psi w.o.g. butterfly valve, wafer body, suitable for dead-end and isolation service.

D. For service valves within steel piping of 3 inch or above; 200 psig w.o.g butterfly valves, installed between standard ANSI Class 125/150 flanges, suitable for dead-end and isolation service without use of downstream flanges. 3 inch through 6 inch size valves to have manual stem position, lock to prevent tampering, notched plate and latching handle while valves of 8 inch size and above shall have manual enclosed weatherproof handwheel actuators with gear box and position indicator window, and all meeting the following criteria.

	Part	**Specifications**
1.	Stem	Stainless Steel, ASTM A-582 Type 410
2.	Collar Bushing	Brass, ASTM B-124
3.	Stem Seal	Teflon or Vitron
4.	Body Seal	Teflon or Vitron
5.	Nameplate	Aluminum

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	Part	Specifications
6.	Upper Bushing	Copper CDA 122
7.	Liner	Teflon or Vitron
8.	Disc	Al. Bronze, ASTM B-148 Alloy 954/955
9.	Lower Bushing	Copper CDA 122
10.	Body (Lug)	Ductile iron, ASTM A-536

E. For check valves within horizontal steel or copper lines through 2 inch size, bronze check valve with teflon disc, threaded ends, Class 150 swp-300 w.o.g., as follows:

	Part	Specifications
1.	Body	Bronze, ASTM B62
2.	Cap	Bronze, ASTM B62
3.	Lever	Bronze, Commercial
4.	Disc	Teflon
5.	Disc Holder	Brass, ASTM B16 1/4 inch & 1/2 inch Bronze, ASTM B62 3/4 inch to 2 inch included
6.	Pin	Stainless Steel, Commercial
7.	Plug	Bronze, ASTM B16
8.	Retaining Ring	Stainless Steel, Commercial
9.	Disc Nut	Bronze, Commercial

F. Optional check valves for vertical type of installation within steel or copper lines, similar to that of above sub-paragraph G, except vertical lift up-flow, bronze with threaded ends.

G. For check valves within steel piping of 2-1/2 inch size and above, for vertical up-flow applications, Class 250 w.o.g flanged iron body flat style silent check; and for horizontal applications, Class 125 w.o.g flanged iron body horizontal swing check.

H. For check valves within copper piping of 2-1/2 inch through 4 inch size, Class 300 w.o.g bronze for horizontal or vertical installation with solder ends.

I. Hot Water Return – Balancing Valves: B&G Circuit Setter-Plus. Leadfree construction, brass valve body with stainless steel ball. Install along with line size check valve. Manufacturers: B&G, Taco, Armstrong, Nexus.

Flow Rates For Valve Sizing:
* flow = 3.0 - 5.0 gpm use Circuit Setter-Plus Model CB-3/4”S-LF
* flow = 6.0 - 10.0 gpm use Circuit Setter-Plus Model CB-1”S-LF
* flow = 11.0 - 15.0 gpm use Circuit Setter-Plus Model CB-1-1/4”S-LF

2.3 NATURAL GAS SYSTEM

A. All types of valves used shall be local utility company as well as AGA approved for the service and pressure intended.

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B. Refer to Section 22 20 00 “Natural Gas Systems”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with manufacturer's written instructions, and all valves must be suitable for the service intended.

B. Provide service (isolation) valve at every piece of equipment. Service valves to be positioned in a manner to allow for ease of service and removal of equipment with minimum disruption of the piping system.

C. All shut-off valves in plumbing water systems 2 inch and smaller shall be ball-type.

END OF SECTION 22 05 23

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SECTION 22 05 29

HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. Work of this Section includes, but is not limited to: Pipe hanger and supports, Pipe and equipment anchors, Pipe sleeves.

1.3 QUALITY ASSURANCE

A. Pipe Hanger Standards: Manufacturers Standardization Society (MSS) SP-58, SP-89, and SP-69, as referenced.

B. SMACNA.

C. NFPA

1.4 SUBMITTALS

A. Shop Drawings: Miscellaneous steel layout. Indicate all point loads where miscellaneous steel is supported by structural members, Brace spacing, layout, connection method and details.

B. Product Data: Catalog cuts and performance data.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

E. Contract Closeout Information: Operating and maintenance data, Warranty.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

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A. Pipe Hangers: Elcen Metal Products Co., B-Line Systems Inc., Carpenter and Paterson Inc., Anvil.

B. Concrete Anchors: Phillips, Hilti.

C. Insulated Pipe Supports: Pipe Shields Inc., Anvil, Power Piping.

D. Pipe and Equipment Anchors: Shop-fabricated, Field-fabricated.

E. Sleeves: Shamrock Industries, "Crete-sleeve" plastic hole forms, Proset Systems Inc., "Proset" fire-safe pipe penetrations, Shop for field fabricated.

F. Sleeves, Pre-Manufactured Fire and Smoke Wall Barrier: Pipe Shields, Inc.

2.2 PIPE HANGERS AND SUPPORTS

A. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Cadmium plated carbon steel, adjustable swivel split ring. Use PVC coated or copper plated for copper piping.

B. Hangers for Pipe Sizes 2 and Over: Carbon steel, adjustable, clevis type. Use copper plated for copper piping.

C. Hangers for piping that gets insulated shall be sized to allow insulation to be continuous through hangers.

D. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

E. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp; adjustable steel yoke and cast iron roll for hot pipe sizes 6 inches and over.

F. Vertical Support: Steel riser clamp.

G. Floor Support for Pipe Sizes to 8 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.

H. Shield for Insulated Piping 2 Inches and Smaller: 18 gage galvanized steel shield over insulation in 180 degree segments, minimum 12 inches long at pipe support.

I. Shields for insulated piping 2 1/2 inches and larger shall be waterproof hydrous calcium silicate, encased in 360° galvanized steel shield.

2.3 HANGER RODS AND ATTACHMENTS

A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded. Use cadmium plated rods where unconcealed or exposed to the elements.

B. Minimum pipe hanger rod sizes are as follows:

Pipe Size	Rod Diameter

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Pipe Size	Rod Diameter
Up to 2 Inches	3/8 Inch
2-1/2 Inches & 3 Inches	1/2 Inch
4 Inches	5/8 Inch
6 Inches	3/4 Inch
8 Inches to 12 Inches	7/8 Inch

C. Beam Clamps (up to 8-inch diameter pipe): Top beam clamp, steel jaw, hook rod with nut and spring washer steel eye-bolt. C-clamps by themselves are expressly prohibited unless otherwise approved by Structural Engineer

2.4 INSERTS

A. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.5 PIPE SLEEVES AND SEALANTS

A. Sleeves – General: Sleeve all piping passing through walls, floors, roofs, foundations, footings and grade beams sufficient to allow free movement of piping. Box out openings larger than 14 inch diameter.

B. Sleeves, Steel Pipes: Use in following locations:
1. Fire-rated and smoke-rated construction.
2. Structural steel members (when approved by A/E).
3. Floors: Galvanized.
4. Concrete walls.
5. Mechanical rooms, tunnels, and stairwells.
6. Polyethylene hole forms (Crete-Sleeve): Optional use in poured concrete walls and floors.

C. Sleeves for Plastic Piping
1. Provide pipe sleeves for all plastic-type piping (PVC, CPVC and polypropylene) at fire-rated assembly and floor slab penetrations.
2. Size sleeves per following schedule:

Pipe Size (In.)	Sleeve Size (In.)	Extension Beyond Barrier (Ft.)
1 or less	3	2
1-1/4 to 2	4	2
3	5	3
4	6	4

3. Extend sleeve listed distance beyond wall or floor on both sides.
4. Insulate plastic pipe with minimum 1 inch thick calcium silicate or 2400 deg F aluminasilica within sleeve length.

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D. Sleeves, pre-manufactured fire and smoke wall barrier: Optional, similar to Pipe Shields, Inc.
   1. Bare Pipe through Fire Walls and Floors: Model WFB, DFB, or QDFB.
   2. Insulated Pipe through Fire Walls and Floors: Model WFB, DFB, or QDFB.
      a. Insulated chilled water and DX lines: Type CS-CW.
      b. Other insulated pipes: Type CS.
   3. Plastic Pipe through Fire Walls and Floors: Type WFB with 1-inch-thick calcium silicate insulation encased in metal sleeve extension 2 ft. either side of fire-rated walls or floor.

E. Sleeve Sizes
   1. Length: Ends flush with finished surfaces.
   2. Diameter
      a. Minimum 3 inch.
      b. Minimum 1 inch larger than pipe and pipe insulation.
      c. In concrete, 1-1/2 inch larger than pipe.
      d. Diameter suitable for construction tolerances and to receive sealant, when indicated.

F. Sealants: Seal annular space around piping.
   1. For fire- and smoke-rated floors, walls and partitions: Use UL-listed firestopping material that maintains fire-rated wall and floor integrity. Provide proper material for each typical application as described by manufacturer.
   2. Acceptable Manufacturers: Dow Corning "Fire Stop", Nelson "Flameseal", 3M "Fire Barrier", Pipe Shields Inc., Model WFB, DFB, or QDFB Series, Proset Systems.
   3. For Non-Rated Walls and Partitions: Use mineral or glass fiber insulation.
   4. For Exterior and Foundation Walls: Use synthetic rubber seals, "Link-Seal" waterproof material or system.

PART 3 - EXECUTION

3.1 GENERAL

A. Structural Considerations
   1. Steel or concrete roof/floor system, including slabs or roof deck shall be in place and complete before installation of any mechanical piping system.
   2. Space hangers so maximum individual hanger load will not exceed values listed in paragraph "Pipe Hanger Loading."
   3. Do not attach hangers to steel roof deck.
   4. Do not attach hangers to bottom of concrete filled floor deck, except by permission of A/E.
   5. Attach hangers to beams whenever possible.

B. Install piping systems with approved hangers and supports to prevent sagging, warping and vibration of piping systems. Install pipe hangers and supports to allow for expansion, contraction, and drainage of piping. Place hangers and supports close to valves, vertical riser drops, heavy equipment, specialties, and each piping change of direction.

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C. Connect hanger rods to approved "I" beams or channel clamps, concrete inserts or expansion shields. Provide all concrete inserts and structural members required for the proper support of the piping systems with proper approved distribution of weight.

D. Do not weld to structural steel without special permission of the A/E. Do not use wooden plugs for any form of fastening.

E. Space pipe hangers for horizontal piping as indicated, unless otherwise directed. Provide pipe hangers with the minimum rod sizes shown, complete with full length machined threads, and adjusting and lock nuts.

F. Run piping substantially as shown on the Drawings. Run pipe as directly as possible, avoiding unnecessary offsets and interferences, maintaining maximum headroom and concealed in all rooms or areas, except mechanical equipment rooms, unless otherwise noted. Coordinate exact locations of mains, risers and runouts in the field with the various Trade Contractors and the A/E.

G. Arrange pipe lines to give ample room for pipe insulation. Run piping parallel to or at right angles with the lines of the building.

H. Assemble and install piping without undue strain and stress and with provision for expansion, contraction and structural settlement. Do not cut or notch structural members unless adequate provision is made with the approval of the A/E. Anchors shall be approved by the A/E before they are used.

3.2 PIPE HANGERS AND SUPPORTS

A. For standard steel and copper piping, locate hangers at each change of direction as well as within remaining lengths spaced at or within following maximum limits:

Pipe Diameter	Standard Steel Liquid	Vapor	Copper Liquid	Copper Vapor
1/2 - 1 inch	7 ft.	8 ft.	5 ft.	6 ft.
1-1/4 - 2 inch	7 ft.	9 ft.	7 ft.	9 ft.
2-1/2 - 3 inch	11 ft.	14 ft.	9 ft.	13 ft.
3-1/2 - 4 inch	13 ft.	16 ft.	11 ft.	15 ft.
5 - 6 inch	16 ft.	19 ft.	13 ft.	18 ft.
8 - 14 inch	16 ft.	24 ft.	16 ft.	16 ft.
	16 in		20 ft.	24 ft.

B. For Schedule 40 or Schedule 80 PVC piping, locate hangers at each change of direction and space at or within the following maximum limits:

Schedule 40 or 80 PVC		
Pipe Diameter	Liquid	Vapor

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Schedule 40 or 80 PVC		
Pipe Diameter	**Liquid**	**Vapor**
1/2 - 1 inch	3 Ft.	3 Ft.
1-1/4 - 2 inch	3 Ft.	3 Ft.
2-1/2 - 3 inch	6 Ft.	6 Ft.
3-1/2 - 4 inch	7 Ft.	7 Ft.
5 - 6 inch	8 Ft.	8 Ft.
8 - 14 inch	12 Ft.	12 Ft.

C. Provide a hanger within one (1) foot or less of each horizontal elbow and valves that are above three (3) inches in size. If spacing between horizontal elbows (or plugged tees used as elbows) is less than six (6) feet, provide only one (1) hanger located between the elbows. No hanger size or requirements shall ever be less than the minimum recommended by the Mechanical Contractor's Association of America, Inc.

D. For cast iron pressure piping, space maximum 12 feet o.c. Provide minimum of one hanger per pipe section close to joint on barrel and at change of direction and branch connections.

E. For cast iron soil piping, space maximum 10 feet o.c. Provide minimum of one hanger per pipe section close to joint on barrel and at change of direction and branch connections.

F. For piping of other materials, space hangers according to manufacturer's recommendations.

G. Pipe Hanger Loading

1. Total hanger rod load (including piping, insulation, and fluid) not exceeding following limits:

Nominal Rod Diameter	Maximum Load
3/8 inch	610 lb.
1/2 inch	1,130 lb.
5/8 inch	1,810 lb.
3/4 inch	2,710 lb.

2. Do not exceed manufacturer's recommended maximum safe load if smaller than above.

H. Trapeze Hangers: Suspend trapeze hangers from concrete inserts of approved structural clips. Construct trapeze hangers of galvanized angle iron, channels or other structural shapes with flat surfaces for point of support.

I. Vertical Pipe Supports: Support all vertical pipe runs in pipe chases at base of riser. Support pipes for lateral movement with clamps or brackets.

J. Concrete Inserts: Provide individual or continuous slot concrete inserts for use with hangers for piping and equipment exposed in finished areas, and as required. Provide concrete inserts in time for installation in concrete.

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3.3 ANCHORS

A. All connections to the structure shall be sized according to actual applied load plus any seismic vertical component increase.

B. Pipe Anchors: Provide as indicated and required to permit complete installation of system. Do not anchor piping to plaster or gypsum wallboard partition walls. Provide anchoring devices at locations indicated. Do not use powder driven fasteners, expansion nails, or friction spring clamps.

3.4 MISCELLANEOUS STEEL

A. Piping Contractor (or Plumbing Contractor, as applicable) to provide all miscellaneous steel as required to accommodate pipe supports and hangers.

B. Provide Shop Drawings detailing miscellaneous steel layout and connection to structural members. Indicate all point loads where miscellaneous steel is supported by structural members.

C. All miscellaneous steel to be galvanized steel. Repair galvanized steel at field cuts and connections.

END OF SECTION 22 05 29

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SECTION 22 05 53

PIPE AND EQUIPMENT IDENTIFICATION

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. Work of this Section includes, but is not limited to: Piping identification, Valve identification, Equipment identification.

1.3 QUALITY ASSURANCE

A. Piping System Identification: ANSI A13.1-1981, "Scheme for the Identification of Piping Systems."

1.4 SUBMITTALS

A. Shop Drawings: Not required for review.

B. Product Data: Manufacturer's cut sheets and/or literature.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

E. Contract Closeout Information: Valve chart showing valve numbers, type, and location.

PART 2 - PRODUCTS

2.1 PIPE MARKERS

A. Conform to ANSI A13.1-81.
   1. Pressure-sensitive vinyl (self-sticking) material.
   2. Mechanically Fastened Type: Snap-on or strap-on. For dirty greasy, oily pipe where pressure-sensitive markers may not perform satisfactorily.
   3. Provide with direction of flow arrows.
   4. Size of Letters Legend

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Outside Diameter of Pipe or Pipe Covering	Length of Color Field	Size of Letters and Arrows
3/4 to 1-1/4 inch	8 inch	1/2 inch
1-1/2 to 2 inch	8 inch	3/4 inch
2-1/2 to 6 inch	12 inch	1-1/4 inch
8 to 10 inch	24 inch	2-1/2 inch
Over 10 inch	32 inch	3-1/2 inch

2.2 VALVE TAGS

A. Brass or Anodized Aluminum Type
   1. Brass: Minimum 19 ga, polished, 1-1/2-inch diameter with following lettering:
      a. Service: 1/4 inch stamped black filled letters.
      b. Valve numbers: 1/2 inch stamped black filled letters.
   2. Aluminum: 2-inch diameter, 0.032 inch thick, with following lettering:
      a. Service: 1/4 inch engraved letters.
      b. Valve numbers: 1/2 inch engraved letters.

B. Valve Tag Fasteners: 4-ply 0.018 copper or monel wire meter seals, brass "S" hooks or No. 16 brass jack chain.

2.3 EQUIPMENT NAME PLATES

A. 1/16-inch rigid plastic "Setonply," "Emedolite," or bakelite with 4 edges beveled, or engraved aluminum with black enamel background and natural aluminum border and letters.
   1. Two 3/8-inch mounting holes.
   2. Lettering size: Minimum 1/2-inch high.
   3. Fasteners: Commercial quality, rust-resisting nuts and bolts with backwashers and self-tapping screws or rivets.

2.4 CHART AND DIAGRAM FRAMES

A. Extruded aluminum with plexiglass or glass windows.

2.5 ACCEPTABLE MANUFACTURERS

A. Pipe, Valve, and Equipment Markers: Craftmark Identification Systems, W. H. Brady Co, EMED Company, Inc., Kolbi Industries, Inc., 3M Co., Seton Name Plate Corp.

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PART 3 - EXECUTION

3.1 VALVE AND EQUIPMENT IDENTIFICATION

A. Designate all equipment and valves by distinguishing numbers and letters on charts and/or diagrams. Tag and locate following equipment items: Valves, All items indicated on drawing equipment schedules.

B. Install tags on all devices with numbers and letters corresponding to charts.

C. Fasten tags securely to devices with tag fasteners in manner for easy reading.

D. Attach equipment nameplates in conspicuous location on item of equipment or apparatus such as starters, pumps, and control panels. Secure nameplates with self-tapping screws, or nuts and bolts.

E. For unsuitable conditions, such as high temperature or lack of space, use copper or brass rings or chains to attach tags.

F. Furnish 4 charts including device number, location (room number, department) and purpose. Mount 1 chart in frame and secure on wall in location directed by Owner. Include remaining 3 sets in "Operation and Maintenance Manuals."

G. Provide all devices located above ceilings with additional identification. Use access panel markers (metal-tack-style) for acoustical tile ceilings, or engraved plastic style, 3/4 inch square, for mounting on panel door. Coordinate with Owner on identification method and color codes.

3.2 PIPE IDENTIFICATION

A. Soil, waste, and vent piping do not require color coded paint or bands.

B. Locate pipe markers as follows:
1. Next to each valve and fitting, except on plumbing fixtures and equipment.
2. At each branch or riser take-off.
3. At each passage through walls, floors, and ceilings.
4. At each pipe passage to underground.
5. On all horizontal pipe runs every 20 ft., at least once in each room and each story traversed by piping system.
6. Identify piping contents, flow direction, supply and return.

C. Install markers with tape color bands over each end of marker, extending around pipe and overlapping a minimum of 30 degrees.

D. Where supplementary color identification of medical gas piping is used, paint in accordance with gases and colors indicated in CGA Pamphlet C-9.

3.3 SERVICE ABBREVIATIONS

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A. General

1.	CW	Domestic Cold Water
2.	HW (___)	Domestic Hot Water Supply (indicate temperature)
3.	HWC	Domestic Hot Water Circulating
4.	P	Discharge Plumbing-Sump Pump/Sewage Ejector
5.	G	Natural Gas

END OF SECTION 22 05 53

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SECTION 22 05 61

PREPARATION OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CLEANING AND PREPARATION FOR SERVICE

A. Flushing Mains. Immediately upon completion of the water distribution system, test valves to ensure their full opening. Flush the system as follows: Open valve and permit the flow to continue until the water runs clear. Repeat the operation at the next valve and proceed in order to the valve farthest from the source of supply. Use outlets in building to flush the upper ends of mains and service lines. During such flushing operation, the A/E may test the flows from valves and, before final acceptance of the work, make further tests of flows to ascertain that lines are clear.

B. Interior and Exterior Sterilization of Water Distribution System. After the water distribution system has been flushed, sterilize the system by the following or other, more rigid methods satisfactory to the A/E and the State and Local Plumbing Authorities.
   1. Introduce chlorine or a solution of calcium or sodium hypochlorite, filling the lines slowly and applying the sterilizing agent at a rate of 50 parts per million of chlorine, as determined by residual chlorine tests at the ends of the lines. Open and close all valves and hydrants while chlorinating the system.
   2. After sterilization agent has been applied for 24 hours, test for residual chlorine at the ends of the lines. If less than 25 ppm is indicated, repeat the sterilization process.
   3. When tests show at least 25 ppm of residual chlorine, flush the system until all traces of the chemical are removed.

C. The Owner reserves the right to require testing of the water again at any time prior to final acceptance of the work and, if found bacteriologically unsafe, to require the Contractor to re-chlorinate the system until the water is proven equal to that supplied by the public system.

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3.2 SANITARY WASTE/VENT AND STORM DRAINAGE SYSTEMS

A. Test systems as recommended by Local and State Plumbing Inspection Authorities.

3.3 OPERATIONAL TEST

A. Upon completion of and prior to acceptance of the installation, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:
   1. Time, date, and duration of test.
   2. Water pressure at the most remote and the highest fixtures.
   3. Operation of each fixture and fixture trim.
   4. Operation of each valve, hydrant, and faucet.
   5. Pump suction and discharge pressures.
   6. Temperature of each domestic hot water supply.
   7. Operation of each floor and roof drain by flooding with water.
   8. Operation of each vacuum breaker and backflow preventer.

END OF SECTION 22 05 61

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SECTION 22 07 00

PLUMBING PIPE INSULATION

PART 1 - GENERAL

1.1 REFERENCE STANDARDS

A. ASTM International (ASTM).

B. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE).

C. North American Insulation Manufacturers Association (NAIMA).

D. NAIMA – "Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation".

E. "National Commercial & Industrial Insulation Standards" – MICA Manual.

F. National Fire Protection Association (NFPA).

G. Underwriter's Laboratories (UL).

H. Underwriter's Laboratories Environment (UL Environment).

All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. Work of this Section includes, but is not limited to: Pipe insulation, Equipment insulation, Insulation adhesives, mastics and caulking.

B. Definitions
   1. Concealed Insulated Surfaces: Piping and equipment in walls, partitions, floors, pipe chases, pipe shafts, duct shafts, sealed alleyways, and above suspended ceilings.
   2. Exposed Insulated Surfaces: Piping and equipment located in mechanical rooms, tunnels, and rooms without suspended ceilings.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics with a minimum of 10 years field experience who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

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B. Products shall not contain formaldehyde, asbestos, lead, mercury, or mercury compounds [if available]. Products shall be Certified UL GREENGUARD Gold or Indoor Advantage Gold [if available].

C. Recycled Content: A minimum of 50 percent recycled glass content certified and UL Validated.

D. Products shall contain no polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE or Deca-BDE fire retardants; whenever available.

E. Comply with fire and smoke hazard ratings indicated.
1. Test by procedure ASTM E84, NFPA 255, and UL 723.
2. Accessories such as adhesives, mastics, cements, tapes, and glass fabric, same or better component ratings.
3. Following are rating requirements: Flame spread (maximum): 25, Smoke developed (maximum): 50
4. Properly identify products and/or their shipping cartons for flame and smoke ratings.
5. Where prohibited by code or local ordinances, do not use elastomeric-type insulation anywhere within ceiling plenum return air systems.

1.4 SUBMITTALS

A. Shop Drawings: Submit schedule indicating service, application, thickness and finishes.

B. Product Data: Manufacturer's cut sheets and literature, Performance data.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

E. Contract Close-Out Information: Manufacturer's installation, maintenance, and painting data, Guarantees.

F. EPD or HPD Submittals: Third Party Validated.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Glass Fiber Pipe Covering: Knauf Insulation, Manville, Owens-Corning, Manson,

B. Fire-Retardant Adhesive: Manville, Benjamin Foster, 3M, Insul-Coustic, Childers.

C. Lagging Adhesive: Manville, Benjamin Foster, Borden, Insul-Coustic.

D. Elastomeric Pipe Insulation and Equipment Covering: Armstrong Armaflex, IMCOA, Imcolock, Ultrafoam.

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E. Insulated Fitting Covers: Knauf Proto, Manville, Certain-Teed,

F. Insulation Caulking: Dow No. 11.

2.2 GENERAL

A. Provide fire and smoke hazard ratings as indicated for entire composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation).

B. Do not use material that exceeds specified flame and smoke ratings.

C. Use permanent treatments to jackets or facings to impart specified fire ratings.

D. Use of water-soluble treatments is prohibited.

E. At Hangers and Bracing: See Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment".

2.3 PIPE INSULATION, NON-FLEXIBLE

A. Pipe Insulation, Non-flexible
1. Knauf Insulation Earthwool 1000 Pipe Insulation ASJ+/SSL+ pipe insulation Thermal conductivity (K value): Not greater than 0.23 at mean temperature of 75 deg F.
2. Insulation thicknesses shall meet the minimum suggested requirements of ASHRAE 90.1 2013, IECC 2015 or local code requirements.
3. Apply to the following piping in thickness indicated:

a. Domestic Potable & non-potable Cold Water:

Pipe Size	**Insulation Thickness**
2 inch and smaller	1/2 inch
2-1/2 inch and larger	1 inch

b. Domestic Hot/Recirculating Water (thru 140 deg F):

Pipe Size	**Insulation Thickness**
1-1/2 inch and smaller	1 inch
2-1/2 inch and larger	1-1/2 inch

c. **Storm Water Piping**: Including all vertical and horizontal rain leaders shall be 1 inch.

2.4 PIPE INSULATION, FLEXIBLE

A. Pipe Insulation, Flexible
1. Armstrong self-seal AP Armaflex flexible elastomeric pipe insulation.

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2. Thermal conductivity (K value): Not greater than 0.27 at mean temperature of 75 deg F.
3. Apply to following piping in thickness indicated: Waste piping from water coolers and drinking fountains: All sizes 1/2 inch

2.5 INSULATION FOR COLD EQUIPMENT

A. Insulation for Cold Equipment:
1. Armstrong Armaflex II sheet insulation; 1-1/2 inch material installed in 2 layers with joints staggered.
2. Thermal conductivity (K value): Not greater than 0.27 at mean temperature of 75 deg F.
3. Apply to following equipment a thickness of 3/4 inch: Domestic water meter, Roof drain bodies

2.6 INSULATION FASTENERS

A. Insulation Adhesive: Childers CP-82.

B. Insulation Mastic: Childers CP-30.

C. Insulation Caulking: Dow No. 11.

PART 3 - EXECUTION

3.1 APPLICATION - GENERAL

A. Do not insulate piping until satisfactory completion of required pressure tests.

B. Apply insulation to clean, dry surfaces with pipe surfaces at room temperature.

C. Butt insulation firmly together with longitudinal and end joints sealed with compatible jackets, facings and adhesives as specified.

D. Apply adhesives, mastics and coatings per manufacturer's recommendations and as specified.

E. On cold surfaces where vapor barrier jackets are used, apply insulation with a continuous, unbroken vapor seal. Adequately insulate and vapor seal hangers, supports, and anchors that are secured directly to cold surfaces to prevent condensation.

F. Continue insulation through sleeves and wall and ceiling openings except insulation shall not continue through fire-rated (2-hour or greater) partitions, walls, floor-ceiling systems.

G. Insulate all fittings, valve bodies, flanges and other pipeline accessories.

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H. At hangers and bracing, install in accord with Division 22 Section “Hangers and Supports for Plumbing Piping and Equipment”.

I. Contractors shall consult manufacturer's Technical Bulletins for detailed information on safety precautions in using all insulation products, polyurethanes, polyisocyanurates, and related materials. The data shall describe fire and other risks, safety in handling, toxicity, threshold limit values, physiological effects of inhalation and eye and skin contact, incompatibilities and other essential information regarding use. Obtain six (6) copies for distribution and use at jobsite and for submittal with shop drawing submittals.

J. Roof Conductors: Insulate all horizontal and vertical piping.

3.2 FIBERGLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes.

1. Secure pipe insulation to pipe using self-sealing lap system.
2. On high temperature piping, above 500 deg. F (260 deg. C), apply insulation using double layer and staggered joints. For double layer installation, secure the unjacketed inner layer using filament tape; without deforming insulation material. All joints and ends must be firmly butted and secured with appropriate securing material.
3. Firmly rub all longitudinal and circumferential joints using a squeegee or sealing tool.
4. Longitudinal jacket laps for pipe insulation installed on piping systems with operating temperatures below ambient shall be vapor sealed with factory-applied pressure sensitive adhesive vapor retarder, self-sealing lap. For proper sealing, firmly rub lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool. Vapor seal all circumferential joints with factory-furnished, matching pressure sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool. Additionally, coat raw edges of pipe insulation sections with vapor retarder mastic at
12 foot (3.6 m) to 21 foot (6.4 m) intervals; at Engineer's discretion on straight piping, and on either side of all fittings, flanges, or valves. Vapor retarder mastic shall completely coat the ends of the pipe and extend onto the bore of the pipe insulation and onto the jacketing a minimum of 2 inches (51 mm). Follow NAIMA's "Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation" for additional details.
5. Install metal shields between hangers or supports and the pipe insulation. Install rigid insulation inserts as required between the pipe and the insulation shields. Inserts shall be of equal thickness to the adjacent insulation, and shall be vapor sealed as required. Insulation shields shall be no less than the following lengths:

    a. 1-1/2 inch to 2-1/2 inch IPS: 10 inch (254 mm) long.
    b. 3 inch to 6 inch IPS: 12 inch long.
    c. 8 inch to 10 inch IPS: 16 inch long.
    d. 12 inch and over IPS: 22 inch long

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6. For piping subject to abuse in mechanical rooms or high traffic areas, protect insulation from mechanical abuse by the use of appropriate thickness of PVC jacketing, metal jacketing, or laminated self-adhesive water and weather seal.

7. For piping exposed to the elements, install a jacket that shall be UV resistant PVC with a minimum thickness of 0.030 inch, a minimum 0.016 inch thick aluminum jacket with factory-applied moisture barrier, or a minimum 0.010 inch thick stainless steel jacket with factory-applied moisture barrier. Fittings shall be of similar materials or outdoor weatherable PVC. Apply all jacketing per manufacturer's recommendations for the conditions.

B. Insulation Installation for Pipe Flanges:

1. Install preformed 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 fiberglass blanket insulation.
4. Install jacket material using 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 preformed formaldehyde free fiberglass fittings; minimum 50 percent recycled glass content, of same material as straight segments of pipe insulation when available.
2. When preformed 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 Fittings:

1. Install preformed formaldehyde free fiberglass fittings; minimum 50 percent recycled glass content, of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered 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.

E. PIPE & TANK INSULATION

1. Apply on clean, dry surfaces.
2. Cut to appropriate length using manufacturers’ stretch out guide for the specific pipe size. Add an additional 2 inches to 4 inches (102 mm) for a staple flap.
3. Install insulation around the duct circumference in a manner that ensures a firm fiber mesh at all joints. Fasten the longitudinal with outward clinching staples placed 3 inches on center. As an alternative, individual sections may be fastened

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in place using continuous and overlapping strands of ¾" wide glass fiber filament tape around the insulation jacketing O.D. Longitudinal and circumferential joints shall be sealed with 4" wide matching pressure sensitive tape squeegeed along the entire length.

4. For duct exposed to the elements, jacketing shall be UV resistant PVC with a minimum thickness of 0.030 inches, or 0.016 inches thick aluminum with factory applied moisture barrier or 0.010 inches thick stainless steel with a factory applied moisture barrier or laminated self-adhesive water and weather seals. Fitting covers shall be of similar materials. The insulation and jacketing shall be held firmly in place with a friction type Z lock or a minimum 2″ overlap joint. For systems operating below ambient, all PVC joints shall be sealed completely along the longitudinal and circumferential seams and installed so as to shed water. When required, all PVC circumferential joints shall be sealed by use of preformed butt strips; minimum 2″ wide or a minimum 2″ overlap. Butt strips shall overlap the adjacent jacketing a minimum ½ inch and be completely weather sealed. PVC Jacketing shall be limited to a maximum 20 inch OD of the insulation when exposed to direct sunlight. For systems operating above ambient, circumferential joints should overlap a minimum of 2″ and not be sealed. Insulation thickness for duct covered by PVC Jacketing shall be such that the surface temperature of the PVC does not exceed 125°F (52°C).
5. On below ambient straight duct, vapor retarder mastic shall be applied to raw glass fiber ends at 12 foot to 21 foot intervals; at the Engineer's discretion, and on either side of fittings, flanges or valves before taping. Mastic shall extend a minimum of 2 inches onto the bore of the pipe and 2 inches onto the jacketing.

3.3 APPLICATION OF FLEXIBLE PIPE INSULATION

A. Install tubing wherever possible by slipping material over piping. Otherwise, slit pipe insulation, tightly butt ends and seal butt joints and slit seams with suitable adhesive.

B. Insulate fittings and valve bodies with segments cut from pipe insulation. Apply with adhesive.

C. Insulate piping at hanger points with fiberglass material protected with metal saddles.

3.4 APPLICATION OF INSULATION ON COLD EQUIPMENT

A. Apply with Armstrong 520 adhesive covering entire surface as well as back of insulation.

B. Coat all butt edges and press firmly together with 1/8-inch overlay pressure.

C. Apply two (2) coats of Armstrong Armaflex finish over sheet surfaces.

END OF SECTION 22 07 00

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SECTION 22 11 16

DOMESTIC WATER PIPING AND DEVICES

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. This Section applies to:

1. Potable Cold Water Piping
2. Hot Water Piping
3. Hot Water Recirculation Piping
4. Raw Cold Water Piping
5. Interior Hose Bibbs (HB-1), (HB-2)
6. Exterior Wall Hydrants (WH-1)
7. Water Meter
8. Strainers
9. Water Hamer Arrestors
10. Vacuum Breaker
12. Drain Valves
13. Temperature and Pressure Relief Valves
14. Pressure Reducing Valve
15. Escutcheons

1.3 QUALITY ASSURANCE

A. General: Provide all supervision, labor, tools, materials, equipment, accessories and specialties necessary to completely install, clean and test the plumbing systems. All materials shall be free from defects impairing strength and durability and shall be of the best quality for the indicated purposes. All Work shall have structural properties sufficient to solely sustain or withstand strain and stresses to which it is normally subjected; all Work shall be true to detail.

B. Codes and Standards (Division 22 Section “Common Work Results for Plumbing” Listings and the following).
   1. Plumbing installation shall be in accordance with the state and local plumbing code, and all other codes having jurisdiction.
   2. American Standard Code for Pressure Piping ANSI B31.1

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3. National Association of Corrosion Engineers
4. American National Standards Institute (ANSI)
5. American Society of Mechanical Engineers (ASME)
6. American Society for Testing and Materials (ASTM)
7. American Water Works Association
8. Manufacturer's Standardization Society of the Valve and Fitting Industry
9. Plumbing and Drainage Institute
10. State Plumbing Code
11. State Building Code

C. Material Standards
1. ASTM B32-94: Specification for Solder, Metal Sizes.
2. ASTM B42-93: Specification for Seamless Copper Pipe, Standard Size.
3. ASTM B75-93: Specification for Seamless Copper Tube.
4. ASTM B88-93a: Specification for Seamless Copper Water Tube.
5. ASTM B251-93: Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.
6. ASTM B302-92: Specification for Threadless Copper Pipe.
7. ASTM A53-94: Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated Welded and Seamless.
8. AWWA C651-92: Standard for Disinfecting Water Mains.

1.4 SUBMITTALS

A. Shop Drawings: Valves: Submit in separate packages for each service/schedule as specified.

B. Product Data: Catalog cuts.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

1.5 HANDLING, DELIVERY, AND STORAGE

A. General: Handling, delivery, and storage shall be in accordance with the manufacturer's recommendations. No extra cost shall be charged the Owner for handling, delivery, or storage. In no case shall the pipe or appurtenance be dumped, dropped, or thrown.

PART 2 - PRODUCTS

2.1 PIPING

A. General: The outside of all piping and fittings shall bear the Manufacturer's standard marking for type, pressure, etc. The A/E does not guarantee the accuracy of the figure numbers as listed.

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B. Pipe - General
1. All carbon steel pipe shall be fabricated from open hearth or electrical furnaces. No Bessemer pipe shall be installed.
2. All pipe and fittings shall be equal to or better than the grade specified.
3. Whenever Specifications call for close bending or coiling, use Grade B pipe.
4. All piping material shall be new and free from defects and shall be subject to standard mill test before being shipped.
5. Pipe shall be labeled.
6. Fittings and valves shall have the Manufacturer's name or trademark legibly raised or cut into each piece.
7. All pipe shall be cut off even and reamed full bore. Threads shall be cut smooth, true and to full standard size. Piping shall be installed clean of chips, burrs or oil.
8. No salvaged or used pipe shall be used without the written approval of the A/E or Owner. Wherever such approval is given, recut the ends of the pipe, square, cut new threads on screwed pipe, and thoroughly clean the pipe of all rust, dirt, scale and foreign matter before installation.

C. Domestic Water Pipe 4-inch Size and Smaller
1. **Pipe:**
a. Copper tube, seamless, type L hard temper, ASTM B-88, above ground, and type K soft temper, 2-inch and smaller, below ground.
b. Copper Press-Connect, ASME B16.51
2. **Fittings**:
a. Cast brass or wrought copper, solder type, ASTM 75, ANSI B16.22..
3. **Joints:** Soldered, 95-5 tin-antimony solder above ground, and silver solder below ground.
4. **Unions:** Sweat-end, 150 lb. cast brass, ground joint.

Press Fittings
Manufacturers: Pro-Press, Apollo, Streamline, Viega
1. Pipe: Copper press fittings may be used as an option, per ASTM B16.18 or ASTM B16.22.
Fittings: Press-Type fittings shall be joined using appropriate sized Tools per ASTM B88. Manufacturers: ProPress
2. Mechanically formed tee connections and couplings, such as T-drill, are NOT acceptable.

2.2 PIPING AUXILIARIES / SPECIALTIES

A. General: All auxiliaries and specialties shall be guaranteed by the manufacturer for the pressure, temperature and materials being handled. All auxiliaries and specialties shall be suitable for the piping to which they are attached.

B. Interior Hose Bibbs: Manufacturers: Woodford, Chicago, Crane, Nibco, or Mifab.

C. Wall Hydrants: Manufacturers: Josam, J.R. Smith, Wade, Woodford, Mifab or Zurn.

D. Water Meter: Meter is purchased from the utility company and installed by the Plumbing Contractor. Provide meter installation meeting utility company requirements.

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E. Strainers: Manufacturers: Sarco, Anderson, Armstrong, Crane, or Watts. Sarco type BT or BF-150, bronze body with stainless steel screen. Provide drain valve on strainer.

F. Vacuum Breakers
1. Manufacturers: Watts, Chicago Faucet, Febco, Wilkins, Conbraco, or Woodford.
2. Hose Connections: ASSE 1011, Watts #8A, 3/4-inch hose thread. (#8AC in finished areas).
3. Pressure Type Vacuum Breaker: ASSE 1020, Watts #800QT with ball valves and gauge cocks for 1-1/4 inch thru 2 inch size. ASSE 1056, Watts #008QT anti-spill-type for 1/2 inch through 1 inch size.

G. Drain Valves: Powell 502-HS with cap and chain, or equal by Hammond, Keystone, or Watts.

H. Temperature and Pressure Relief Valves: ASME-coded, All-bronze construction with seat-to-disc alignment that will not stick or freeze. Shall start to open at 230 deg F and shall be fully open at 240 deg F. Shall have snap action thermostat and sensing bulb sized to water heater Manufacturer's recommendations. Manufacturers: Watts, McDonnel, Wilkins, Conbraco.

I. Pressure Reducing Valve: Valve shall automatically reduce a higher inlet pressure to a steady lower downstream pressure. Must meet “Reduction of Lead in Drinking Water Act”. All bronze body and cover. Outlet pressure shall be set to 65.0 psi Manufacturer: Cla-Val Model CRD-L for sizes 1/2” to 2-1/2” pipe sizes

J. Escutcheons shall be one-piece, steel type with polished, chrome-plated finish and setscrew fastener. Install pipe escutcheons at ALL pipe penetrations thru walls that are visible by public view.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. General
1. Comply with Division 22 Section “Common Work Results for Plumbing”, as well as the requirements of Division 22 Sections “Hangers and Supports for Plumbing Piping, and “Plumbing Insulation”.
2. Piping shall be installed in a manner which permits easy removal of valves and disconnection of equipment. Unions or flanged joints shall be installed for this purpose.
3. Piping shall be installed, supported, guided, and anchored to properly provide for movement due to expansion and contraction without undue strains on the joints and in such a manner that it will not sag, buckle or sway.
4. Piping shall not be supported from other pipes, conduits, ducts or similar installations.
5. No piping shall be supported by the equipment to which it is connected. Install base elbows, hangers or other approved independent method of support for the pipe.

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6. Connections to equipment shall be arranged to facilitate ease of removal and service without dismantling of the run-outs of main piping, and shall be installed by the use of multiple elbows or other similar methods to minimize strain on the equipment connections.
7. No field-fabricated welding fittings shall be permitted. All welding tees, elbows, reducers, and caps shall be commercially manufactured products.
8. Do not obstruct passageways, headroom, door and window operation, and similar areas with the installation of the piping.
9. All open ends of pipes, including equipment connections, shall be properly sealed at all times during installation to keep dirt and all foreign material out of the piping. Plugs used shall be commercially manufactured products.
10. Pipe size reductions shall be made with factory-fabricated eccentric reducers or reducing fittings and shall be installed in a manner which does not cause pocketing or inhibit the flow of the material.
11. Install shut-off service valves with unions on all connections to equipment and on each side of control valves as required for ease of proper servicing and maintenance; see Division 22 Section “General Duty Valves for Plumbing Piping”.
12. Unless otherwise indicated, the discharge from pressure-and temperature-relief valves and equipment drains shall be piped to the nearest floor drain, hub drain, or mop sink, installed with an approved air gap as required, and arranged for safe discharge.
13. No pipe shall penetrate any structural member without the written approval of the A/E. Where such penetration is allowed, the structural member shall be reinforced subject to the approval of the A/E.
14. Dielectric Separation: Provide dielectric separation at all copper piping and valves connected to ferrous piping. Brass or bronze valves installed in ferrous piping shall not require dielectric separation. Connections between copper piping and ferrous flanged piping and equipment connections shall be with a bronze companion flange with dielectric separation for flanges and bolts. Connections between copper piping and screwed ferrous piping shall be Clearflow Dielectric Waterway fittings.
15. Movement: Mains: Provide adequate offsets, bends, loops, flexible joints and guides as required to prevent over-stressing of piping and/or the structure. Branches: Provide for expansion and contraction by means of offsets, swings, joints or loops to eliminate stress on connected piping, valves or equipment. Provide for proper drainage as required. Maintain a free floating, properly braced and supported piping system.
16. Provide all rough-in and final connections to equipment and services indicated in the Contract Documents for equipment and services to be functional.
17. Pipe Sleeves shall be installed at ALL pipe penetrations of floors.

B. Cross Connections and Interconnections: No plumbing fixtures, devices, equipment or pipe connections shall be installed that will provide a cross-connection or interconnection between a potable water supply and any source of nonpotable water such as a drainage system, a soil or waste pipe, or a boiler or cooling tower where the water may be chemically treated.

C. Painting of Piping: Refer to Division 09 Section “Interior Painting”.

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3.2 BUILDING PIPING SYSTEM: INSTALLATION

A. Domestic Water: Cold, Hot, Recirculating: All piping shall be installed and pitched to provide proper drainage. Install drain valves at all low points and as required to provide drainage facilities for the piping. Wherever system is sectionalized, install drain valves between each sectional shut-off valve. All hot water piping shall be pitched to provide natural gravity recirculation regardless of a recirculation pump. Install pressure gauge in domestic cold water main at water entrances to building.

B. Shock Elimination: All piping shall be protected against water shock. Install a water hammer arrestor of the proper size at the end of the main, at the end of all branch lines, and at the end of lines serving groups of fixtures. Water hammer arrestors shall be sized and installed as recommended by the Plumbing and Drainage Institute, and shall eliminate water hammer. All water hammer arrestors shall be installed in locations where they are readily accessible for service. Where required, provide suitable access doors.

C. Contamination Protection: Provide an approved in-line double check backflow preventer at each connection to a fixture where indicated or required by code. Such fixtures shall include coffee makers, ice makers, clothes washers, etc.

D. Backflow Prevention: Install a code approved backflow preventer unit in the service main, where indicated on the Drawings, or as required by code. Include in-line strainer, dual-service shut-off valves, double-check valves, and check cocks. Install pressure gauge on inlet and outlet side of backflow preventor. Properly support unit, independent of the piping, with union connections.

E. Water Meter: Arrange for and pay all costs involved in the installation of a water meter in the building service line, where indicated. Support independent of the piping with union connections. Installation and meter shall be in accord with and approved by the water utility company. The Contractor is responsible for contacting the local water utility for meter setting and coordination of work.

END OF SECTION 22 11 16

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SECTION 22 13 00

SANITARY SEWER SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes specifications for:

1. Floor Drains
2. Trap Guards
3. Floor Sinks
4. Hub Drains
6. Trench Drains
7. Cleanouts
8. Backwater Valves

B. Related Documents:

1. Section 22 11 00 - Water Distribution
2. Section 22 13 00 - Sanitary Sewerage (Sanitary Waste and Vent Piping)
3. Section 22 14 00 - Storm Drainage

1.2 REFERENCE

A. Applicable provisions of all Sections 22 shall govern work under this section.

1.3 REFERENCE STANDARDS

A. ANSI A112.14.1 - Backwater Valves
B. ANSI A112.21.1 - Floor Drains.
C. ANSI A112.21.2 - Roof Drains.
D. ANSI A112.26.1/PDI WH-201 - Water Hammer Arrestors.
E. ASSE 1001 - Pipe Applied Atmospheric Type Vacuum Breakers.
F. ASSE 1010 - Water Hammer Arrestors.
G. ASSE 1011 - Hose Connection Vacuum Breakers.
H. ASSE 1012 - Backflow Preventers with Intermediate Atmospheric Vent.
I. ASSE 1013 - Reduced Pressure Principle Backflow Preventers.
J. ASSE 1018 - Trap Seal Primer Valves.
K. ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining, Anti-Backflow Type.

1.4 QUALITY ASSURANCE

A. Substitution of Materials: Refer to Section GC - General Conditions of the Contract, Equals and Substitutions..

B. Plumbing products requiring approval by the State of Indiana.

1.5 SHOP DRAWINGS

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A. Include data concerning dimensions, capacities, materials of construction, ratings, certifications, weights, manufacturer's installation requirements, manufacturer's performance limitations, and appropriate identification.

1.6 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

2.1 FLOOR DRAINS

Manufacturer: J.R. Smith, Wade, Zurn.

A. Grates and Covers:
1. Medium duty unless specified otherwise) in areas not subject to equipment loads. Secure with vandal resistant screws.
2. Heavy duty (or reinforced) in areas which are subject to heavy equipment loads.
3. Contractor shall coordinate location of drains indicated on plumbing drawings with structural / general contractor.
4. Jails: Areas of inmate access shall have drain strainers secured with tamper resistant screws.
5. See Floor Drain Schedule on drawings for model numbers and drain descriptions.

2.2. PLUMBING DRAINS

A. FD-1: Floor Drain. General Duty: (On / Above Grade)
1. Duco cast iron bottom outlet body, with double drainage flashing flange and reversible clamping collar, with 5” round adjustable nickel bronze strainer assembly. Strainer diameter to be a minimum twice the outlet size of the outlet connection.
2. Provide with cast iron p-trap or approved equal.
3. Provide with trap-primer connection.
4. Shower Drains connected to a PVC piping system maybe ProFlo (# PF140nc) no caulk shower drain and snap-in stainless steel strainer, install with drain trap.
5. Floor drain is to be provided with either a J.R Smith Stink-Stopper # 2692 or SureSeal-backcheck for sewer gas control.

B. FD-2: Floor Drain. – Ice Machine Drain with anti-floor rim
1. Duco cast iron bottom outlet body, with double drainage flashing flange and reversible clamping collar, with round adjustable nickel bronze strainer assembly. Note: Strainer diameter to be a minimum twice the outlet size of the outlet connection. Provide with trap-primer connection.
2. Provide with cast iron p-trap or approved equal.

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C. FD-3: Floor Drain: (On Grade)
1. Duco cast iron body with integral deep seal cast iron p-trap, with flashing flange and clamping collar, with round adjustable nickel bronze strainer, with round 5" adjustable nickel bronze strainer.
2. Strainer to be secured with vandal-resistant "torx-screws"
3. Provide with trap-primer connection.

D. FD-4: Equipment Drain with Funnel: (On Grade)
1. Duco cast iron body with integral deep seal cast iron p-trap, with flashing flange and clamping collar, with round adjustable nickel bronze strainer, with round adjustable nickel bronze cleanout plug with solid secured cover.
2. Install 4" diameter nickel bronze funnel assembly.
3. Provide with trap-primer connection.

E. FD-5: Large Capacity Drain:
1. Cast iron flanged receptor, bottom outlet body, with nickel bronze dome strainer.
2. Install half-grate unit.
3. Provide with trap-primer connection.
4. Outlet size shall be 4"

F. FD-6: Large Capacity Drain:
1. Duco cast iron bottom outlet body with double drainage flange and reversible clamping collar.
2. Install with 8" dia. strainer
3. Provide with trap-primer connection.
4. Outlet size shall be 4"
5.

G. AD-1: Area Drain:
1. Cast iron body with hinged, lockable grate and flashing clamp
2. Outlet size shall be 3"
3. Sediment bucket not required.

2.3 TRAP GUARDS

Manufacturer: Manufacturer: JR Smith Quad Close, model #2692 Series, or Sure-Seal # SS2009V with new back-check cover.

Flexible elastomeric PVC construction diaphragm trap guard for installation in new and existing floor drains, hub drains, and trench drains. Trap guard to prevent trap evaporation and waste backflow. Size as applicable to the drain outlet size, up to 4" size. This product to be tested and certified to the requirements of ASSE 1072 & IAPMO Research and Testing, Inc., and any subsequent submittal must contain a certificate of compliance listing all the approved sizes.

Contractor to verify with local plumbing inspector that flexible type trap guard devices are

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allowed. When the use of trap guard devices are not allowed, install a “Watts” Series A200, flow-thru trap primer.

2.4 HUB DRAINS (Where Indicted)

A. Manufacturer: Josam, Smith, Wade, Watts, Zurn.
   1. HD-1: 3“ min. cast iron hub section up 2” min. above floor level, with full-sized P-trap.
   2. HD-2: same as HD-2 except with the addition of a ball float type backwater valve. Zurn Z-415-U (modified) / Z-1099 (no-hub).

2.5 TRENCH DRAINS

TD-1: Trench Drain: Fabricated Stainless Steel Linear, shallow body drain. Drain overall dimension shall be 34” in length with a grating length of 32” and a 2” center outlet discharge drain. Provide with a stainless steel, standard slotted grate and stainless steel overlay rails, modified with vandal resistant stainless steel bolts and locking devices. Trench drains are classified as light-duty per ASME Standard A112.6.3. Trench drain locations are typical for all ADA cells and Padded cell. See drawing Drain Schedule for additional information.

a. Manufacturers: Zurn # ZS880 or ABT, Inc. Polydrain.
b. Grating shall be locked down with vandal resistant screws.
c. Grating shall be centered on door or shower opening.

TD-2: Exterior Trench Drain: High Density Polyethylene Structural Composite, 80” modular channel sections with 40” grate sections. Grate shal be slotted – galvanized ductile iron.

a. Manufacturers: Zurn # Z883-GD or ABT, Inc. Polydrain.
b. Grating shall be locked down with vandal resistant screws.
c. Grating shall be centered on exterior door.

TD-3: Laundry Room Trench Drain:
a. Manufacturers: Zurn # Z883-GD or ABT, Inc. Polydrain.
b. Length of grating shall be as indicated on drawing detail.

TRENCH DRAINS

1. TD-1: Trench Drain: Fabricated Stainless Steel Linear, shallow body drain. Drain overall dimension shall be 34” in length with a grating length of 32” and a 2” center outlet discharge drain. Provide with a stainless steel, standard slotted grate and stainless steel overlay rails, modified with vandal resistant stainless steel bolts and locking devices. Trench drains are classified as light-duty per ASME Standard A112.6.3. Trench

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drain locations are typical for all ADA cells and Padded cell. See drawing Drain Schedule for additional information.

a. Manufacturers: Zurn # ZS880 or ABT, Inc. Polydrain.
b. Grating shall be locked down with vandal resistant screws.
c. Grating shall be centered on door or shower opening.

2.6 CLEANOUTS

Manufacturer: Josam, J.R. Smith, Wade, Watts, Zurn.

EXTERIOR UNPAVED AREAS: CO-1, Cast iron hub or plug with tapered threaded PVC closure plug, cast iron or PVC frost sleeve and cover set in 24" square by 4" min. thick reinforced concrete pad top. Neenah R-1976 with non-ferrous securing screw.

INTERIOR CONCRETE FLOOR AREAS: CO-2, Enameled cast iron body with round adjustable scoriated polished nickel bronze cover, tapered threaded ABS closure plug. Zurn ZN-1400- / ZN-1400-T.

INTERIOR FINISHED WALL AREAS: Line type cleanout tee with tapered threaded ABS cleanout plug, round polished stainless steel access cover secured with machine screw. Zurn Z-1446- (Note: Screw shall not pass completely through the ABS plug, trim screw as necessary)

INTERIOR EXPOSED VERTICAL STACKS: Line type cleanout tee with tapered threaded ABS closure plug. Zurn Z-1445.

INTERIOR HORIZONTAL LINES: Cast iron hub with tapped ferrule and tapered threaded ABS or PVC closure plug, or no-hub coupling and blind plug.

PART 3 - EXECUTION

3.1 INSTALLATION

Coordinate location and setting of plumbing specialties with adjacent construction. Install in accordance with manufacturers recommendations.

Set floor drains, roof drains, trench drains and cleanouts level and plumb adjusted to finished floor elevation, roof elevation or finished wall location. Locate where serviceable. Allow minimum of 18" clearance around cleanouts for rodding. Lubricate threaded cleanout plugs with graphite and oil, teflon tape or waterproof grease. Install trap primer connections where indicated. Provide deep seal traps on floor drains and hub drains installed in mechanical rooms, penthouses or rooms with excessive positive or negative pressure.

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Floor drains and hub drains installed in public restrooms, locker rooms, seldom used rooms, and areas with minute drainage flow shall have a trap guard device installed.

During construction, floor drains and drench drains shall be protected from dirt and debris. Contractor shall cover drains with temporary tape or coverings to be removed once construction is complete.

Adjust receiver height to drain tile inlet and outlet elevations and cleanout to finished floor elevation.

Floor Drains FD-1, FD-3, FD-6 shall be installed to allow the strainer to be recessed 1/4” below finished floor. Drain shall have a slopped 12” sweep around outside diameter of strainer.

END OF SECTION

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SECTION 22 13 16

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.
3. Encasement for underground metal piping.

1.2 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.
2. Waste, Force-Main Piping: 100 psig.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: (When Required) For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

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B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

1.6 MANUFACTURERS

A. Charlotte Pipe and Foundry Co., North American Pipe Corp.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than five days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Construction Manager's and Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 **PIPING BELOW GRADE**:

1. HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

(NOTE: Use Cast-Iron Piping Only Where Indicated on Drawings, Such As Kitchen and Laundry Areas.)

A. Pipe and Fittings: ASTM A 74, CISPI, Service and Extra Heavy classes.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29

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2. PVC PIPE AND FITTINGS

A. Pipe: Solid wall Schedule 40 PVC.

B. Pipe Compound: ASTM D1784 Cell Class 12454.

C. End Type: Belled

D. Lay Length: Max. 10 ft.

2.3 **PIPING ABOVE GRADE:**

PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Solvent Cement: ASTM D 2564.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections 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, Non-pressure Transition Couplings:

a. Manufacturers:

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1) Dallas Specialty & Mfg. Co.
2) Fernco Inc.
3) Mission Rubber Company; a division of MCP Industries, Inc.
4) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
5) Husky

b. Standard: ASTM C 1173.
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. 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.

4. Shielded, Non-pressure Transition Couplings:

a. Manufacturers:

1) Cascade Waterworks Mfg. Co.
2) Mission Rubber Company; a division of MCP Industries, Inc.

b. Standard: ASTM C 1460.
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.

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. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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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. 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. 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. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Exterior Sewers: Maintain a minimum of 42” above top of pipe to finished grade. Verify burial depth of sewer piping with local city / county sewer department.

M. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated: Invert elevations of sanitary waste piping are generally indicated on the Plumbing Foundation drawing.

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

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

O. Install steel piping according to applicable plumbing code.

P. Install aboveground PVC piping according to ASTM D 2665.

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Q. Install underground ABS and PVC piping according to ASTM D 2321.

R. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
2. Install drains in sanitary drainage gravity-flow piping.

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

T. Install sleeves for piping penetrations of walls, ceilings, and floors.

U. Install escutcheons for piping penetrations of walls, ceilings, and floors where exposed to public view.

3.3 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.

C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.

F. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

G. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

H. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

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1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Aboveground Force Main Piping: Fitting-type transition couplings.
3. In Underground Force Main Piping:

    a. Piping 1-1/2” and Smaller: Fitting-type transition couplings.
    b. Piping 2” and Larger: Pressure transition couplings.

3.5 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 drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage 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 drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections 2-1/2” and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping 2” and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping 2” and larger, adjacent to flanged valves and at final connection to each piece of equipment.

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3.6 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 drainage and vent piping according to 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. 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 drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. 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. 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. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. 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.

3.7 CLEANING AND PROTECTION

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

B. Protect drains 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.

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D. Exposed Vent Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 22 13 16

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SECTION 22 14 00

STORM WATER SYSTEMS

P A R T 1 - G E N E R A L

1.1 SCOPE

This section contains specifications for plumbing pipe and pipe fittings for this project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Reference
- Reference Standards
- Shop Drawings
- Quality Assurance
- Delivery, Storage, and Handling
- Design Criteria
- Welder Qualifications

PART 2 - PRODUCTS
- Storm Water Piping
- Roof Drains and Overflow Drains

PART 3 - EXECUTION
- General
- Preparation
- Erection
- Copper Pipe Joints
- Welded Pipe Joints
- Threaded Pipe Joints
- Solvent Welded Pipe Joints
- Mechanical Hubless Pipe Connections
- Mechanical Joint Pipe Connections
- Push-On Gasketed Pipe Connections
- Mechanical Grooved Pipe Connections
- Mechanically Formed Tee Fittings
- Storm and Clearwater Waste and Vent
- Subsoil Drain
- Piping System Leak Tests
- Construction Verification Items

1.2 RELATED WORK

22 05 29 - Hangers and Supports for Plumbing Piping and Equipment
22 05 14 - Plumbing Specialties

1.3 REFERENCE

Applicable provisions of Division 1 govern work under this section.

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1.4 REFERENCE STANDARDS

ASTM A74 Cast Iron Soil Pipe and Fittings
ASTM A105 Forgings, Carbon Steel, for Piping Components
ASTM A126 Gray Cast Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A888 Hubless Cast Iron Soil Pipe and Fittings
ASTM C564 Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C1540 Heavy Duty Shielded Couplings for Joining Hubless Cast Iron Soil Pipe and Fittings
ASTM D1785 Poly Vinyl Chloride (PVC) Plastic Pipe
ASTM D2241 Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2464 Threaded Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466 Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564 Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings
ASTM D2665 Poly Vinyl Chloride (PVC) Plastic Drain, Waste and Vent Pipe and Fittings
ASTM D2729 Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
ASTM D2855 Making Solvent Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings
ASTM D3034 Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
ASTM D3139 Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3311 Drain, Waste and Vent (DWV) Plastic Fitting Patterns
ASTM F437 Threaded Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438 Socket Type Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F441 Chlorinated Poly Vinyl Chloride (CPVC Plastic Pipe, Schedules 40 and 80
ASTM F656 Primers for Use in Solvent Cement Joints of Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings

1.5 SHOP DRAWINGS

Schedule from the contractor indicating the ASTM, AWWA or CISPI specification number of the pipe being proposed along with its type and grade if known at the time of submittal, and sufficient information to indicate the type and rating of fittings for each service.

Statement from manufacturer on his letterhead that pipe furnished meets the ASTM, AWWA or CISPI specification contained in this section.

1.6 QUALITY ASSURANCE

Substitution of Materials: Refer to Section GC – General Conditions of the Contract, Equals and Substitutions.

Order all copper, cast iron, steel, PVC and polyethylene pipe with each length marked with the name or trademark of the manufacturer and type of pipe; with each shipping unit marked with the purchase order number, metal or alloy designation, temper, size, and name of supplier.

Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the State.

1.7 DELIVERY, STORAGE, AND HANDLING

Promptly inspect shipments to insure that the material is undamaged and complies with specifications.

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Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

Offsite storage agreements will not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

1.8 DESIGN CRITERIA

A. Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM OR AWWA specifications as listed in this specification.

P A R T 2 - P R O D U C T S

STORM WATER PIPING

2.1 INTERIOR ABOVE GROUND:

Manufacturers: North American Pipe Corp., Harvel Plastics Inc., Genova Products, Cresline or approved equal.

1. PVC plastic pipe, Schedule 40, Class 12454-B (PVC 1120), ASTM D1785; PVC plastic drain, waste and vent pipe and fittings, ASTM D2665; fitting patterns, ASTM F656; solvent cement,

2. Joints: Pipe ends for solvent cemented joints. ASTM D2564

2.2 INTERIOR BELOW GROUND 15" AND SMALLER:

Manufacturers: North American Pipe Corp., Harvel Plastics Inc., Genova Products, Cresline or approved equal.

1. PVC plastic pipe, Schedule 40, Class 12454-B (PVC 1120), ASTM D1785; PVC plastic drain, waste and vent pipe and fittings, ASTM D2665; fitting patterns, ASTM D3311; primer, ASTM F656; solvent cement, ASTM D2564.

2. Joints: All PVC pipe joints shall be gasketed, bell-and-spigot, push-on type conforming to ASTM D3212, “Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.” Gaskets may be factory installed or field installed as recommended by the pipe manufacturer. Lubricant shall be as recommended by the pipe manufacturer.

2.3 ROOF DRAINS:

The roof drain shall have a beehive or dome shaped strainer with integral flange not less than 12

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inches in diameter. For an insulated roof, a roof drain with an adjustable drainage collar shall be provided, which can be raised or lowered to meet required insulation heights, sump receiver and deck clamp. The Bottom section shall serve as roof drain during construction before insulation is installed.

A. Manufacturers:
   1. Jay R. Smith
   2. Zurn
   3. Josam
   4. Substitutions: Section 01600 - Product Requirements.

B. Roof Drain (RD-1): "Roof –Drain"
   1. Assembly: ASME A112.21.2M.
   2. Body: Galvanized cast iron with sump.
      J.R. Smith #1010.
   3. Strainer: Removable cast aluminum dome.
   4. Accessories: Coordinate with roofing type.
      a. Membrane flange and membrane clamp with integral gravel stop.
      b. Adjustable under deck clamp.
      c. Roof sump receiver.
      d. Waterproofing flange.
      e. Controlled flow weir.
      f. Leveling frame.
      g. Adjustable extension sleeve for roof insulation.
      h. Perforated or slotted ballast guard extension for inverted roof.
      i. Perforated stainless steel ballast guard extension (where indicated on drawings).

C. Roof Drain (RD-2): "Over-Flow Drain"
   1. Assembly: ASME A112.21.2M.
   2. Body: Galvanized cast iron with sump.
      J.R. Smith #1080.
   3. Strainer: Removable cast aluminum dome.
   4. Pipe or dam extended to 2 inches above flood elevation.
   5. Accessories: Coordinate with roofing type.
      a. Membrane flange and membrane clamp with integral gravel stop.
      b. Adjustable under deck clamp.
      c. Roof sump receiver.
      d. Waterproofing flange.
      e. Controlled flow weir.
      f. Leveling frame.
      g. Adjustable extension sleeve for roof insulation.
      h. Perforated or slotted ballast guard extension for inverted roof.
      i. Perforated stainless steel ballast guard extension (where indicated on drawings).

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PART 3 - EXECUTION

3.1 GENERAL

Install pipe and fittings in accordance with reference standards, manufacturer's recommendations and recognized industry practices.

3.2 PREPARATION

Cut pipe ends square. Ream ends of piping to remove burrs. Clean scale and dirt from interior and exterior of each section of pipe and fitting prior to assembly.

3.3 INSTALLATION

Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. In all cases, consult drawings for location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Provide a full size cleanout at the base of each Roof Conductor.

Install underground warning tape 6"-12" below finished grade above all exterior below ground piping. Where existing underground warning tape is encountered, repair and replace.

Maintain piping in clean condition internally during construction.

Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.

Do not route piping through or above transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment.

Note: Insulate roof drains, overflow drains and all horizontal portions of the storm water piping system.

3.4 PUSH-ON GASKETED PIPE CONNECTIONS

Clean pipe end, bell, gasket seat and gasket of dirt or debris. Coat end of pipe and gasket with gasket lubricant. Insure pipe is supported off the ground so lubricant does not pick up dirt. Push spigot end into gasket bell with levered pipe joining tool recommended by pipe manufacturer. Large diameter exterior mains may be joined by pushing end of pipe section with backhoe against wood blocking over pipe end. Insert to fully seated position or to reference mark on pipe.

3.5 STORM AND CLEARWATER - DEPTH

Verify invert elevations and building elevations prior to installation. Install exterior piping pitched to drain at indicated elevations and slope. Install interior piping pitched to drain at minimum slope of 1/8" per foot for piping 3" and larger.

Install exterior piping below predicted frost level and not less than 3' bury depth to top of pipe wherever possible.

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3.6 PIPING SYSTEM LEAK TESTS

Do not insulate or conceal pipe until it has been successfully tested.

For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

System will not be approved until it can be demonstrated that there is no measurable loss of test pressure during the test period.

Inspect system for leaks. Where leaks occur, repair the area with new materials and repeat the test; caulking will not be acceptable.

Entire test must be witnessed by the Owner's representative and the Project Engineer.

	Test	Initial Test		Final Test	
System	Medium	Pressure	Duration	Pressure	Duration
Clearwater Waste and Vent	Water	N/A		10' water	2 hr
Storm and Clearwater Waste	Water	N/A		10' water	2 hr
Pressurized Storm/Clearwater	Waste	Water	N/A		100 psig 2 hr

END OF SECTION

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SECTION 22 20 00

NATURAL GAS SYSTEMS

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to, Division 01, General Requirements.

1.2 JOB CONDITIONS

A. Coordinate the exact location of this work with the work of other trades before fabrication and installation. Verify all dimensions and elevations. Provide additional offsets and section of piping as may be required to meet the applicable job conditions. Coordinate with and review all related drawings of all trades before starting work.

1.3 SUBMITTALS

A. Shop Drawings: Not required for review.

B. Product Data: Manufacturer's cut sheets and/or literature.

C. Samples: Not required for review.

D. Reference Submittals: Not required for review.

1.4 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
D. Installer Qualifications: Company specializing in performing the Work of this Section with minimum three (3) years documented experience.
E. Conformance to National Fuel Gas Code.
F. Material and installation requirements shall follow NFPA 54, state and local gas company codes.
G. Conformance to ANSI B31.
H. Gas regulators shall be AGA rated.

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PART 2 - PRODUCTS

2.1 PIPING - ASTM A 53/A 53M, BLACK STEEL, SCHEDULE 40

A. Below-ground pipe 5 feet from the building to above-ground at the building shall be Schedule 40 welded-joint steel pipe with factory-applied protective coating, such as X-Trucote. Joints shall be field-coated with the same material applied as recommended by the manufacturer. If underground gas distribution pipe is steel, provide a dielectric union at point of connection. Install a 17-pound anode pack between the building and 5 feet outside the building next to the connection to the main service pipe. Attach the anode lead wire to the piping by means of an exothermic weld, following the instructions of the manufacturer.

B. Above-Ground Gas Piping: Standard weight, Schedule 40, welded or screwed, black carbon steel pipe, ANSI/ASTM A53.
1. 1-1/2 inches and smaller: 150 lb. screwed malleable black iron fittings.
2. 1-1/2 inches and smaller in concealed spaces: Schedule 40 black steel with socket welded fittings.
3. 2 inches to 2-1/2 inches: 150 lb. screwed malleable black iron fittings.
3 inches: Welded or forged steel butt welded, pipe and fitting,

or

Viega: MegaPressG Black Steel Press-Connect Fittings for Fuel Gas Distribution Systems. Shall be listed to ANSI LC4/CSA 6.32.

C. All concealed piping shall be welded.

D. All gas piping exposed to outside weather environment shall be protected from corrosion by application of a non-metallic-based painting system specifically designed and manufactured for protection of steel piping.

1. Apply two finish coats of Rust-O-Leum, Krylon, or De Rusto heavy duty paint. Allow proper drying time between coats

2. Color as selected by Owner. The union of the underground coating and above-ground paint shall be at least 2 inches above finished grade.

E. Gas piping within the building shall be electrically continuous and bonded to a grounding electrode.

2.2 VALVES, REGULATORS AND ACCESSORIES

A. Gas cocks shall be lubricated plug.

B. Valves: Shut-off Valves sizes 2 inches and smaller shall be iron body lubricated plug valve conforming to ASTM-A-126, U.L. Listed and A.G.A. Approved for natural gas

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service with threaded ends, wrench operation, rated for 200 WOG service pressure and –20 to 200 degrees F.

C. Valves: Shut-off Valves sizes 2½ inches and larger shall be iron body lubricated plug valve conforming to ASTM-A-126, U.L. Listed and A.G.A. Approved for natural gas service with flanged ends, wrench operation, rated for 200 WOG service pressure and –20 to 200 degrees F.

D. Valves at local connections sizes 2 inches and smaller shall be bronze body, full port ball or butterfly type, U.L. Listed and A.G.A. Approved for natural gas service with threaded ends, quarter turn lever handle operation, rated for 175 W.O.G. service pressure and 30 to 275 degrees F

E. Gas Pressure Regulators: Shall be as manufactured by Pietro-Fiorentini, Senus or Fisher. Regulators shall have cast iron body, die-cast aluminum alloy diaphragm case and aluminum or brass orifices. Line pressure is typically 2.0 psig with regulator spring adjustable and selected for an outlet pressure of 7-inch to 14-inch W.C.

1. Regulators to be similar to Pietro-Fiorentini - Model # PF400 with vent limiter feature to eliminate external vent piping system.

F. When required by regulator manufacturer, properly vent gas pressure regulators to the outdoor atmosphere with screened vent caps.

G. Provide nickel-plated steel plates on exposed pipes passing through walls, ceilings, floors, and partitions.

H. Regulators shall be installed with a line-size plug valve, a pressure gauge on inlet side of regulator and a pressure gauge on the outlet side at least ten pipe diameters from the regulator.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Gas piping system installation shall conform to the Standard for the Installation of Gas Appliances and Gas Piping USA Z21.30, ANSI Z106.1, NFPA No. 54 and No. 58, the rules of local and state regulatory agencies governing the installation of gas piping, the Gas Utility Energy Code for indirect gas service, and local gas utility company.

B. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Design locations and arrangements of piping take into consideration pipe sizing, flow direction, slope of pipe, expansion, and other design considerations. So far as practical, install piping as indicated.

C. Concealed Locations: Except as specified below, install gas piping (in masonry walls) in an airtight conduit constructed of Schedule 40 seamless black steel with welded joints. Vent conduit to the outside and terminate with a screened vent cap.

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1. Above-Ceiling Locations: Gas piping may be installed in accessible above-ceiling spaces (subject to the approval of the authority having jurisdiction), whether or not such spaces are used as a plenum. Valves shall not be located in such spaces. Piping in plenums shall be welded.
2. In Floors: Piping installed in floors shall have protective wrapping specified in PART 2 above. Piping cast in concrete slabs shall be surrounded with a minimum of 1-1/2 inches of concrete and shall not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Piping shall not be embedded in concrete slabs containing quick-set additives or cinder aggregate. Piping shall be welded.
3. Piping in Partitions: Concealed piping shall not be located in solid partitions.
4. Prohibited Locations: Do not install gas piping in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumbwaiter or elevator shaft. This does not apply to accessible above-ceiling space specified above.

D. Sleeves
1. Set sleeves during construction of walls, floors and foundations.
2. If a hole is required after the structure is cast, its location and size shall be approved by the A/E. Core-drill the hole. Maintain the fire integrity of the structure.
3. Where pipes pass through building construction, use proper length and gauge pipe sleeves of galvanized steel. Anchor sleeves to building construction. Size anchors to permit passage of insulation where insulation is required. Maintain the fire integrity of walls, floors, ceilings, and partitions.
4. Where pipes pass through foundation walls and footings, provide cast iron sleeve and caulk the space between sleeve and pipe with lead wool, watertight.
5. Install sleeves in floors perfectly plumb and in walls level. Center the pipe in the sleeve. Pack sleeves with fire-rated materials, per shop-drawing-approved submittals, and caulk in tight.
6. Extend floor sleeves only 3/8 inch to 1/2 inch above finished floors. Neatly level tops of sleeves.
7. Finish wall and partition sleeves flush with wall lines.

E. Seal pipe penetrations of fire barriers using fire barrier penetration sealers specified in Division 07 Section “Joint Sealants”.

F. Drips and Sediment Traps
1. Install a drip leg at points where condensate may collect, at the outlet of the gas meter, and in a location readily accessible to permit cleaning and emptying. Do not install drips where condensate is likely to freeze.
2. Construct drips and sediment traps using a tee fitting with the bottom outlet plugged or capped. Use a minimum of 3 pipe diameters in length for the drip leg. Use same size pipe for drip leg as the connected pipe.
3. Drip legs at equipment connections shall be down stream of valve.

G. Use fittings for all changes in direction and all branch connections.

H. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

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I. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

J. Piping in walls shall be free of any joints or fittings. The concealed pipe space must be ventilated with either an open wall top, or a wall louver/grille installed.

K. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

L. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

M. Install gas piping at a uniform grade of 1/4 inch in 15 feet, upward to risers, and from the risers to the meter, or service regulator when meter is not provided, or the equipment.

N. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

O. Connect branch outlet pipes from the top or sides of horizontal lines, not from the bottom.

P. Conform to the table below for maximum spacing of supports:

Steel Pipe Size (NPS)	Spacing in Feet	Min Rod Size Inches
1/2	6	3/8
3/4 to 1-1/4	6	3/8
1-1/2 to 3 (horizontal)	12	1/2
3-1/2 to 5 all sizes (vertical)	Every floor level	

Q. Install unions in threaded pipes, adjacent to each valve, at final connections to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

R. Install dielectric unions where piping of dissimilar metals are joined.

S. Install flanges in welded piping, on valves, apparatus, and final connections to each piece of equipment.

T. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, and elsewhere as indicated.

U. When gas supplies and regulators are indicated to serve a gas-fired water heater a separate regulator (line-size) is required for each water heater supply line.

3.2 PIPE JOINT CONSTRUCTION

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A. Welded Joints: Comply with the requirements in ASME Boiler and Pressure Vessel Code, Section IX.

B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field-cut threads. Join pipe, fittings, and valves as follows:
   1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint. Refer to NFPA 54, for guide for number and length of threads for field threading steel pipe.
   2. Align threads at point of assembly.
   3. Apply appropriate tape to thread compound to the external pipe threads.
   4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.
   5. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

D. Flexible Hose Connections: Provide as a mean for final connection of gas piping to gas-fired, movable Kitchen equipment. Provide flexible gas hose, moveable grade, braider, PVC coated, with 304 stainless steel connectors. NSF/ANSI 169 and ANSI Z21.69.CA 6.16

   Manufacturers: Dormont (Blue-Hose).

3.3 VALVE APPLICATIONS

A. General: The drawings indicate valve types, locations, and arrangements.

B. Shut-off Duty: Use gas cocks specified in PART 2 above.

3.4 VALVE INSTALLATIONS

A. Install valves in accessible locations, protected from physical damage. Tag valves with a metal tag attached with a metal chain indicating the piping systems supplied.

B. Install a gas cock upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve is not required at the second regulator.

C. Install pressure relief or pressure limiting devices so they can be readily operated to determine if the valve is free; so they can be tested to determine the pressure at which they will operate; and examined for leakage when in the closed position.

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3.5 TERMINAL EQUIPMENT CONNECTIONS

A. Install gas cock upstream and within 6 feet of gas appliance. Install a union or flanged connection downstream from the gas cock to permit removal of controls.

B. Sediment Traps: Install a tee fitting with the bottom outlet plugged or capped as close to the inlet of the gas appliance as practical. Drip leg shall be a minimum of 3 pipe diameters in length. Sediment shall be downstream of shut-off valve.

3.6 ELECTRICAL BONDING AND GROUNDING

A. Install above-ground portions of gas piping systems, upstream from equipment shut-off valves electrically continuous and bonded to a grounding electrode in accordance with NFPA 70 - "National Electrical Code."

B. Conform to NFPA 70, National Electrical Code, for electrical connections between wiring and electrically-operated control devices.

3.7 FIELD QUALITY CONTROL

A. Piping Tests: Inspect, test, and purge natural gas systems in accordance with NFPA 54 and local utility requirements.

END OF SECTION 22 20 00

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SECTION 22 30 00

PLUMBING EQUIPMENT

P A R T 1 - G E N E R A L

1.1 SCOPE

This section includes specifications for:

A. PART 1 – GENERAL
Scope
Related Documents
Reference
Quality Assurance
Shop Drawings
Operation and Maintenance Data

PART 2 – PRODUCTS
a. Water Heaters
b. Storage Tanks
c. Water Softeners
d. Booster Pumps
e. Expansion Tanks
f. Water Meters (Sub-Meters)
g. Circulating Pumps
h. Thermostatic Mixing Valves

PART 3 - EXECUTION
Installation
Construction Verification Items
Functional Performance Testing
Training

1.2 RELATED DOCUMENTS

Section 01 91 01 or 01 91 02 – Commissioning Process
Section 22 08 00 – Commissioning of Plumbing
Section 22 05 23 - General-Duty Valves for Plumbing Piping
Section 22 05 15 - Piping Specialties
Section 22 05 13 - Common Motor Requirements for Plumbing Equipment.
Section 22 07 00 - Plumbing Insulation

Division 26 00 00 - Electrical

1.3 REFERENCE

Applicable provisions of Division 1 shall govern work under this section.

Plumbing products requiring approval by the State of Indiana must be approved or have pending approval at the time of shop drawing submission.

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1.4 SHOP DRAWINGS

Include data concerning dimensions, capacities, materials of construction, ratings, certifications, weights, pump curves with net positive suction head requirements, manufacturer's installation requirements, manufacturer's performance limitations, and appropriate identification.

1.5 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

NOTE: All plumbing products and devices must meet the Federal Public Law 111-380, The Reduction of Lead in Drinking Water Act, effective January 04, 2014.

P A R T 2 - P R O D U C T S

2.1 HIGH EFFICIENCY COMMERCIAL GAS FIRED WATER HEATER

Manufacturers: Lochinvar (Bases of Design), A.O. Smith, Bradford White

The Water Heater shall be a LOCHINVAR ARMOR Model AWN-PM**.** The water heater shall be capable of full modulation firing down to 20% of rated input with a turn down ratio of 5:1.

The Water Heater shall bear the ASME "HLW" stamp and shall be National Board listed for inputs in excess of 200,000 Btu/Hr. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. The stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. A built-in trap shall allow condensation to drain from the heat exchanger assembly. The complete heat exchanger assembly shall carry a five (5) year limited warranty.

The water heater shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.10.3 test standard for the US and Canada. The water heater shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The water heater shall be AHRI certified to 96% thermal efficiency. The water heater shall be certified for indoor installation.

The water heater shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The water heater shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating water heater firing rates for maximum efficiency. The water heater shall operate in a safe condition at a de-rated output with gas supply pressures as low as 4 inches of water column.

The water heater shall utilize a 24 VAC control circuit and components. The control system shall have an electronic display for water heater set-up, water heater status, and water heater diagnostics. All

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components shall be easily accessed and serviceable from the front and top of the jacket. The water heater shall be equipped with; a high limit temperature control certified to UL353, ASME certified pressure relief valve, outlet water temperature sensor, inlet water temperature sensor, a UL 353 certified flue temperature sensor, low water flow protection and built-in freeze protection. The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.

The water heater shall feature the "Smart System" control with a Multi-Colored Graphic LCD display with Navigation Dial and Soft Keys, password security, pump delay with freeze protection, pump exercise, and USB PC port connection. The water heater shall feature night setback for the domestic hot water tank and shall be capable of controlling a building recirculation pump while utilizing the night setback schedule for the building recirculation pump. The water heater shall have the capability to accept a 0-10 VDC input connection for BMS control of modulation or setpoint and enable/disable of the water heater, and a 0-10VDC output of water heater modulation rate. The water heater shall have a built-in cascading sequencer with modulation logic options of "lead lag" or "efficiency optimized". Both modulation logic options should be capable of rotation while maintaining modulation of up to eight water heaters without utilization of an external controller. Supply voltage shall be 120 volt / 60 hertz / single phase.

The water heater shall be equipped with two terminal strips for electrical connection. A low voltage connection board with data points for safety and operating controls, i.e., Auxiliary Relay, Auxiliary Proving Switch, Alarm Contacts, Runtime Contacts, Manual Reset Low Water Cutoff, Flow Switch, High and Low Gas Pressure Switches, Tank Thermostat, Tank Sensor, Building Management System Signal, BACnet Contacts and Cascade Control Circuit. A high voltage terminal strip shall be provided for supply voltage. The high voltage terminal strip plus integral relays are provided for independent control of the Domestic Hot Water Pump and Building Re-circulation Pump.

Install the following accessories on each water heater:
1. Relief valve.
2. Drain valve
3. Thermometer.
4. Concentric vent kit.
5. Stack / Frame kit to conserve footprint of units.
6. Neutralization kit

The water heater's total combined air intake length shall not exceed 100 equivalent feet

The water heater's total combined exhaust venting length shall not exceed 100 equivalent feet.

1. Direct Vent Vertical System: Vertical roof top termination of both the vent and combustion air. The flue shall be CPVC or Stainless Steel sealed vent material terminating at the roof top with the manufacturers specified vent termination. A separate pipe shall supply combustion air directly to the water heater from the outside. The air inlet pipe may be CPVC pipe. The air inlet must terminate on the roof top with the manufacturer's specified air inlet cap.

2.2 ELECTRIC WATER HEATERS

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Manufacturer: Lochinvar, Rheem, State

Type: Point of use, compact, electric water heater. Size and energy requirements are listed on the drawing schedule. Heater shall be provided with the following items.

1. Adjustable Thermostat control
2. Replaceable immersion heating elementsa
3. Glass-Lined steel storage tank
4. Temperature and pressure relief valve.
5. Brass drain valve.
6. Contractor shall furnish and install wall mounting self to support water heater @ min. 7'-0" A.F.F.
7. Contractor shall furnish and install a thermostatic mixing valve to externally control hot water supply.
7. Warranty: 6 year, limited tank and parts.
8. See Water Heater Detail on drawings for additional requirements.

2.4 HOT WATER STORAGE TANKS

Tank shall be a vertical tank, with construction having a storage capacity as indicated on plumbing equipment schedule. The tank shall be constructed with an inner chamber baffle designed to receive all circulation to and from the water heater to eliminate turbulence in the tank. The baffled tank shall supply 80% of tank capacity without a drop in outlet temperature, regardless of rate of draw. Tank shall be constructed in accordance with (Standard) (ASME Boiler and Pressure Vessel Code) requirements as indicated on drawings.

Tank shall have a working pressure of 150 PSI. The interior of Tank shall be glass lined and fired to 1600° F to ensure a molecular fusing of glass and steel, furnished with magnesium anodes and tank shall carry a five (5) year limited warranty.

Tank shall be constructed with a heavy gauge galvanized steel jacket assembly, primed and pre-painted on both sides with a minimum dry film thickness of 0.70 mills. Tank shall be completely encased in a minimum of 2" thick, high density polyurethane foam insulation to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard.
Include with tank:

a. Temperature and Pressure gauge
b. 150 psi temperature and pressure relief valve
c. Size and Capacity: See schedule on drawings.

Manufacturers: O.A. Smith, Lochinvar.

2.5 WATER SOFTENERS

A. Automatic Water Softener System: Complete from inlet to outlet, designed within values scheduled herein; of capacity and arrangement as shown on drawings and

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specified herein; furnished, installed and placed in operation.

Acceptable Manufacturer(s): Puritan, Aqua Systems

B. Softener Tank(s) one piece, nonmetallic, seamless construction with continuous fiberglass roving outer shell; rated at 150 psig at 120 Deg. F.

Minimum connection size: 2" female connections.

C. Brine System: single brine measuring and salt storage tank (min. size 24"x48") with salt platform (sufficiently sized for at least four regenerations at full salting); tank and cover constructed of fiberglass or molded polyethylene; full-operated plastic fitted brine valve for automatic control of brine withdraw and fresh water refill.

D. Electrical Characteristics:
As scheduled and indicated on drawings, typically 120 volt single phase.

E. Control: Brass control "Fleck" valve, cycled to regenerate from one to twelve day period.

F. Softener Tank (Each): Reinforced fiberglass tank with hub and lateral distribution system. See schedule on drawings for size and capacity per tank.
Provide vacuum breaker on discharge pipe for each fiberglass softener tank.

G. Brine Tank: High density polyethylene tank with a non-degradable salt platform. See schedule on drawings for size of brine tank.

H. Control (Typical Each Resin Tank): Alternating, fully programmable, progressive flow design. Brass, piston operated multi-cycle control valves for meter initiated regeneration.

I. Meter: Bronze construction, transmitting low voltage signal to controller.

J. Test Kit: Provide water testing kit to make chemical tests necessary for controlling operation and adjustments of brine dosage.

K. Softening Capacity: See schedule on plumbing drawings.

SOFTENER INSTALLATION

1. Coordinate with plumbing piping and related electrical work to achieve a complete operating system.

2. Install drain piping to nearest floor drain.

3. Resin tank and brine tank(s) shall be installed on 4" high concrete pad, unless noted otherwise.

On Inlet:

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a. Strainer.
b. Pressure gage.
c. Shut-off valve.

On Outlet:
a. Shut-off valve.
b. Pressure gage.
c. Flow meter

4. Contractor shall provide initial salt fill, start water softening system and instruct owner in proper operation and maintenance of unit.

2.6 IN-LINE WET-ROTOR CIRCULATING PUMPS

Manufacturer: Bell and Gossett, Grundfos, Taco, Patterson.

Type: Circulator Pump, Maintenance Free, Wet Rotor, Inlet/Outlet Union, Housing Material Bronze, Max. Temp. 225 F, Max. Working Pressure 150 PSI, Shut-Off @ 15 Ft., Impeller Material Noryl, Thermal Protection, Warranty Length 3 Years.

Housing Material : Bronze, Max. Temp. (F) : 225, Max. Working Pressure (PSI) : 150, Impeller Material: Noryl, Shaft Material : Compliance: Certified For Use In Potable Water Applications.

Motor: Provide pump with impedance protected motor sized for non-overloading over the entire pump curve. Pump shall be single phase power unless otherwise indicated, Furnish, each pump and motor with a nameplate giving the manufacturer's name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current.

Pump: Size and capacity as indicated on drawings, see Pump Schedule.

2.7 DOMESTIC WATER BOOSTER PUMPS

A. Manufacturer: Technoforce @ MT (Xylem), Delta P Carver (DeltaPak ES).

System: a complete factory assembled and tested unit (prewired, tested, requiring a single point electrical connection); simplex constant pressure type booster system; consist of centrifugal in-line, vertical stainless steel pump with open drip-proof motor, pressure control valves, UL 508A listed NEMA-1 control panel with panel-mounted system pressure switches, and required interconnecting non-corrosive piping for a complete package. Stainless steel check valve shall be mounted in pump discharge. Base shall be formed steel with primed and painted finish. Package shall be rated for a maximum working pressure of 150 psig and a maximum operating temperature of 250 Deg F. System designed for minimum of 35 psig suction pressure and be NSF / ANST 61 compliant for drinking water.

1. Set discharge pressure of pump to 65.0 psi
2. Establish 50.0 psi delivery pressure to most remote area.
3. Size and capacity as indicated on drawing Pump Schedule.

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B. Control Panel: include a control power transformer, Hand-Off-Auto (HOA) switch, minimum run timer to prevent short-cycling, automatic pump alternation, a touchscreen panel to indicate system status with multi-level password protection. No water flow shutdown shall be provided via system pressure switch. Panel door-interlocked input disconnect switch and short circuit protection shall be standard on all three-phase packages. System shall start upon a drop in domestic water system pressure and stop upon detection of no water flow. Logic capable of accelerating a pump to rated speed (staging) and decelerating pump to a stop or specific speed (de-staging).

C. Options: include the following:

1. Low suction pressure switch and alarm.
2. Shutoff valve on pump suction and discharge.
3. Pressure tank shall be shipped loose and connected as shown on drawings.
4. Main power disconnect.
5. Single point electrical connection.
6. 24V DC power supply
7. Suction and discharge pressure transducers
8. Capable of communication with building MMS by communications protocal.
9. Data logging.

General: Factory packaged simplex domestic water booster pump with all components fully frame mounted, piped, painted, wired and tested at factory. ANSI/NSF61 certified by CSA.

Type: Vertical in-line stainless steel, multi-stage pump, 300 psig maximum working pressure at operating temperature of 250°F. continuous. The manufacturer shall certify all pump ratings. Pump to operate without excessive noise or vibration.

Shafts: Stainless with tungsten steel sleeve, ceramic bearings.

Seals: Mechanical type, carbon rotating against a stationary elastomer, 250°F maximum continuous operating temperature.

Manifold Piping: Stainless steel 304 piping, schedule 10 or heavier pipe as required to maintain a 3 to 1 safety factor. Final connections to assembly shall be made with flexible suction and discharge braided pipe connectors, suction and discharge pressure gauges and common thermal relief valve piped to floor drain.

Controls: Current sensing control mounted in UL 508A listed, labeled NEMA 1 control panel with the following components: magnetic across the line motor starters with 3 leg overload protection and external resets, starter failure interlocks, H-O-A switches for each pump, single door interlocked disconnect with individual fuses, control circuit transformer with protected secondary, time delays, minimum run timers, adjustable solid state current sensing relays, low suction pressure cutout, pump 1 & 2 automatic alternation, high suction pressure shutdown, 2 sensor differential temperature no-flow shutdown, operating and warning lights, warning alarm. Controller shall have a three phase lightning surge arrestor.

Start-Up: A qualified factory trained certified technician shall perform initial factory start-up and owner training. A factory start-up report must be provided to the owner, dated and signed by the factory technician. Provide 24/7/365 factory certified field service during the warranty period.

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Factory packaged single domestic water booster pump assembly with all components fully frame mounted, piped, painted, wired and tested at factory.

Type: The manufacturer shall certify all pump ratings. All pumps to operate without excessive noise or vibration.

Tank: Booster system shall include a bladder tank for no-flow shutdown.

Impellers: Stainless steel, provide internal thrust balance in each stage.

Motors: Provide pump with open drip-proof motor sized for non-overloading over the entire pump curve. Furnish pump and motor with a nameplate giving the manufacturer's name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current.

VFD: Motor(s) shall have VFD.

Install pump assembly on secure wall mounted platform with vibration isolators. Platform shall be provided and installed by the plumbing contractor.

Isolation Valves: Butterfly or ball valves at inlet and outlet of pump, connections to pump to be 2” in size.

System Sequencing: Upon pressure drop in the piping system the pump shall run to attempt to satisfy demand.

Warranty: Provide factory authorized field warranty service for a period of (12) months after successful completion of the factory start-up test.

2.8 DOMESTIC WATER EXPANSION TANKS

Manufacturer: Bell and Gossett, Wessels, Watts.

Vertical steel pre-charged hydro-pneumatic expansion tank, 125 psi ASME labeled construction, complete with replaceable flexible butyl rubber bladder, system connection fitting, Schrader type air charge fitting, steel base ring stand, factory prime and enamel painted exterior finish, ASME relief valve. Materials exposed to water to be NSF or FDA approved for potable water service. Size as indicated on plumbing drawings.

2.12 THERMOSTATIC MIXING VALVES

A. High/Low Master Manifold System: Provide lead-free, factory assembled and tested thermostatic high-low valves, constructed of bronze body and cap with replaceable corrosion and lime resistant components, including universal mounting capability, equipped with integral check-stops, removable strainers, liquid-filled thermostat with 10 year warranty, dial thermometer.

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Provide wall mounting bracket.

Minimum Flow: 0.5 gpm

Manufacturers: Powers (Hydroguard X-P), Symmons, Lawler.

B. Low Flow Valve: The valve shall be ASSE 1017 listed. Valve shall be lead free construction with integral filter washers and check valve and adjustable cap with locking feature.

Manufacturers: Powers (Series LFLM492), Watts, Delta

P A R T 3 - E X E C U T I O N

3.1 INSTALLATION

Install plumbing equipment where indicated in accordance with manufacturer's recommendations. Coordinate equipment location with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. Locate equipment and arrange plumbing piping to provide access space for servicing all components.

Set commercial water heaters, water softeners, storage tanks and booster pumps on 4” high concrete housekeeping pads. Adjust and level equipment.

Connect equipment to water and drain piping using unions or flanges and isolation valves.

Size temperature and relief valves per CSA ratings. Route Piping of temperature and pressure relief valves to terminate over nearest floor drain or floor as indicated.

Startup and test equipment adjusting operating and safety controls for proper operation.

Cycle softeners and adjust for specified exchange rate, regeneration time, consumption, backflow rate, etc. Provide initial salt fill of brine tank.

Lubricate pumps before startup. Adjust pumps for rated flow. Clean and blowdown strainers after 8 hours of operation.

Adjust compression tank pre-charge to scheduled minimum operating pressure prior to connecting to system.

END OF SECTION

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SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 REFERENCE

A. All applicable requirements of other portions of the Contract Documents apply to the work of this Section, including, but not limited to Division 01, General Requirements.

1.2 DESCRIPTION OF WORK

A. Work of this Section includes, but is not limited to:
   1. Inclusion of all plumbing fixtures, complete and ready for use. All fixtures, except as otherwise specified, shall be constructed of vitreous china with all visible exposed surfaces glazed.
   2. Providing all stops, traps, escutcheons, connections, etc., as are necessary to complete the installation of each fixture, whether such items are listed or not.
   3. Plumbing Trim: All finished exposed faucets, traps, connecting piping, stops, flush valves and other fixture trim shall be chromium-plated brass unless otherwise specified and shall be supported rigidly to fixtures and to walls with matching brackets at not more than 2'-0" center. All fastenings shall be chromium-plated brass or may be 302 stainless steel if of matching color and finish. Faucets shall be furnished as required. Vacuum breakers shall be provided as a part of the fixture trim wherever there is a possibility of back-siphoning.
   4. Fixture Stops: Shut-offs for urinal and water closet flush valves shall be an integral part of the fixture or fitting; shut-offs for all other fixtures shall be loose-key, lock-shield-type. All fixture stops shall be angle- or straight-type adapted for each particular location and shall be located immediately adjacent to the fixture. Use threaded adaptors when used in conjunction with copper tube work.
   5. All exposed screws or fasteners for plumbing fixtures and faucets shall be vandalproof. Contractor shall take care to coordinate this item with his suppliers prior to Shop Drawings submittal.
   6. Aerators, where required for sinks and lavatories shall be vandalproof type.
   7. ADA Showers: Threshold of shower shall not exceed 1/2” for transfer showers, 1/4” for roll-in showers. It is the Contractor’s responsibility to set the floor level of the shower to meet this requirement. Floors may be required to have recess area to set shower unit.
   8. Showers: All showers to be provided with proper studding to secure unit to walls. The space between the bottom of the unit and the sub-floor must be filled with bedding compound to secure and level the unit. Bedding compound shall be Gold Bond Gypsolite Plaster, US Gypsum Structo-Lite Plaster or a thin mortar mix.

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1.3 QUALITY ASSURANCE

A. Meet the requirements of the following:
   1. State Plumbing Code.
   2. State Department of Housing, Buildings and Construction.

B. Material Standards
   1. ANSI/ASME A112.19.2-90: Vitreous China Plumbing Fixtures.
   2. ANSI/ASME A112.19.3-87: Stainless Steel Plumbing Fixtures (Designed for Residential Use).
   3. ANSI/ASME A112.19.M-94: Porcelain Enameled Formed Steel Plumbing Fixtures.
   4. ANSI/ASME A112.19.5-79: Trim for Water Closet Bowls, Tanks, and Urinals.
   5. ANSI/ASSE 1016-90: Performance Requirements for Thermostatic, Pressure Balancing and Combination Control Valves for Bathing Facilities.
   6. ANSI/ASSE 1025-78: Performance Requirements for Diverters for Plumbing Faucets with Hose Spray, Anti-Siphon-Type, Residential Applications.

1.4 SUBMITTALS

A. Shop Drawings: Not required for review.

B. Product Data: Catalog cuts, including all fixture trim.

C. Samples: Not required for review.

D. Project Information: Not required for review.

E. Contract Close-Out Information: Operating and maintenance data, Guarantees

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable Manufacturers
   1. Plumbing Faucets: American Standard, Kohler, Delta, and Moen.
   2. Flush Valves: Sloan and Zurn.
   3. Vitreous China Plumbing Fixtures: American Standard, Kohler and Zurn.
   4. Mop Sinks: Fiat, Stern Williams and Mustee
   5. Water Closet Seats: Church, Bemis, Beneke, and Centoco.
   6. Shower Mixing Valves: Powers, Leonard, Lawler, and Bradley.
   7. Stainless Steel Sinks: Elkay, Just.
   8. Prefabricated Showers: Fiat, Kohler, AquaBath, Clarian.
   9. Carriers: Josam, J.R. Smith, Wade, Watts and Zurn.

B. Plumbing Fixtures – General: Constructed or equipped with anti-siphon devices to prevent siphoning waste material into potable water supply system.

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C. Escutcheons and Plates: Conceal all holes where pipes pass through walls, floors or ceilings; use plates or escutcheons.

D. Piping Exposed in Finished Areas (including fittings and trim): Chromium-plated or nickel-plated brass with polished bright surface.

E. Trim for Lavatories and Sinks: Provide with renewable cartridges.

F. Vitreous Caps: Provide for water closet bolts.

G. Sealant: Silicone-type. See Division 07 Section “Joint Sealants”.

2.2 INSULATION AT HANDICAPPED LAVATORIES

A. Handicapped lavatories exposed waste, hot and cold water supply lines shall be insulated with a molded, flexible vinyl insulation system with all fasteners. Provide insulation for 1-1/4-inch waste offset drain, tailpiece, P-trap and waste arm and 3/8-inch supply tubing and 3/8-inch keyed stop valve. Color shall be as selected by the A/E.

B. Insulation shall comply with ASTM E84 25/450, flame spread index of not more than 25 and a smoke-developed index of not more than 450.

C. Manufacturers/Products: Plumbrex, Truebro, Johns Mansville.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sink manufacturer shall provide proper template to architectural woodwork supplier for cutting of countertop. Plumber shall place sink in countertop and complete faucet and piping.

B. Install all fixtures in accordance with Manufacturer's recommendations.

C. All fixture support carriers shall be of the type necessary to permit adjustment to fit variations in construction. All grounds or special supports necessary for setting fixtures shall be provided before plastering or other finished construction work is begun. All fixtures shall be hung at standard height unless otherwise indicated by the A/E.

D. Minimum fixture connection sizes are shown on the Drawings.

E. Provide fixture carriers and required drainage fittings on all wall hung fixtures. Anchor carriers securely to floor.

F. Where plumbing fixtures abut to walls, floors, and countertops, seal all joints with sealant.

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G. Seal floor sinks to wall and floor with building sealant. Color shall match fixture.

H. Provide anchors behind the wall for flush valve supply piping.

I. Adjust self-sustaining closet seats for proper operation and to sustain in any position.

J. Adjust electric water coolers flow for correct operation and temperature.

K. Insulate the hot and cold water and waste piping under handicapped lavatories.

L. Adjust shower mixing valves for correct leaving water temperature.

M. Coordinate electrical requirement of Kitchen Disposals with electrical contractor.

N. After all fixtures have been set and are ready for use, and before the Contractor leaves the job, he shall thoroughly clean all fixtures furnished and set by him, removing all stickers, rust stains and any other matter or discoloration of fixtures, leaving every part in new condition. He shall, further, adjust all flush valves and other fixture water tempering or balancing at supplies to give proper water flow of fixtures.

END OF SECTION 22 40 00

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SECTION 22 46 00

CORRECTIONAL PLUMBING FIXTURES

PART 1 - GENERAL

1. SUMMARY

a. Section Includes:

1) Lavatory/Water Closet – Combo Units.
2) Detox Toilets.
3) Showers

b. Related Sections:

1) Section 079000 - Joint Protection: Product requirements for calking between fixtures and building components for placement by this Section.
2) Section 221100 - Facility Water Distribution: Supply connections to plumbing fixtures.
3) Section 221300 - Facility Sanitary Sewerage: Waste connections to plumbing fixtures.
4) Section 260503 - Equipment Wiring Connections: Execution requirements for electric connections to sensor valves and faucets specified by this Section.

2. COORDINATION OF WORK WITH DETENTION CELL MANUFACTURER

1) The Detention Cell Manufacturer (DCM) shall provide and install the plumbing fixtures and valve mounting plates for the Steel Detention Cell. The DCM shall furnish associated plumbing devices such as, water isolation valves, P-Traps and flush valves for the plumbing fixtures separate and uninstalled. **These associated devices shall be installed by the Plumbing Contractor at the Project Site.**
2) It is the responsibility of the DCM to properly caulk between the plumbing fixture and the wall and/or wall.
3) The Plumbing Contractor is responsible for adjusting the plumbing fixture for proper flow and compliance.
4) The Plumbing Contractor shall coordinate the rough-in location of all sanitary waste risers (located behind cells) with the DMC and the General Contractor.
5) See Division 11

b. MANUFACTURERS & ASSOCIATED ITEMS.

1. Fixtures:
   a. Willoughby
   b. Metcraft.
   c. Acorn

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2. Flush Valves:
   a. Sloan Valve
   b. Zurn

3. Supply Trim:
   a. Water Valves: Shall be locate valves within 24" of the fixture rough-in locations for hot and cold water.
   b. Control Tubing: Aquaflo "Ultracope" or "Mighty-Flex", or approved equal: (Pre-manufactured vinyl tubing 316, stainless steel braided jacketed with flexible connectors with nickel plated brass swivel ends and 304 stainless steel ferrels may be used to make final connections.
   c. Tempered Water Supply: Correctional fixtures (Combo Units -Lavatories – Showers) shall be supplied with tempered **105 degree** water.

4. Flame/Smoke Rating:
   a. Correctional fixtures adjacent (or exposed) to return air plenum chases (i.e.: behind steel cells, etc.) shall be provided with the following products constructed of materials which have a maximum flame and smoke spread rating of 25/50 per ASTM E84 (Or the contractor shall provide an acceptable fire rated wrapping material.)
5. Waste Piping:
   a. Soil piping from back to back (or immediately adjacent) correctional style water closets (and/or combination water closet and lavatory units) shall discharge into an off-set type soil piping fitting, with an interior full baffle to prevent cross flow (similar to Tyler Pipe Figure No. 6).

6. Pinned Cleanouts:
   a. Shall have a brass plug with stainless steel pin and hardware. Pin insertion shall be gasketed "water tight" at the plug. Provide one pinned cleanout plug on the outlet of each correctional water closet bowl.

7. Hook & Cable:
   a. At the base of each soil stack (or individual water closet outlet) location: Provide 4" test tee with brass cleanout plug, a suspended (sharpened) stainless steel three pronged treble hook, stainless steel air craft cable (length as required) and hardware. Cleanout plug shall be provided with stainless steel all-thread rod (water tight connection) and freely pivoting hardware.

8. Traps & Tubing:
   a. Combination Units which are furnished and installed by the plumbing contractor shall be furnished complete with lavatory P-Traps and all required control tubing.

9. Fixture Sealant:
   a. Seal all fixtures to wall and floor surfaces with sealant, Sealant material shall be vandal resistant, when used on secure fixtures.
   b. Manufacturer: DynaFlex: Pecora DynaFlex-SC, color white.

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3. REFERENCES

a. American National Standards Institute:

1) ANSI A117.1 - Accessible and Usable Buildings and Facilities.
2) ANSI Z124.1 - Plastic Bathtub Units.
3) ANSI Z124.2 - Plastic Shower Units.
4) ANSI Z358.1 - Emergency Eyewash and Shower Equipment.

b. Air-Conditioning and Refrigeration Institute:

1) ARI 1010 - Self-Contained, Mechanically Refrigerated Drinking-Water Coolers.

c. American Society of Mechanical Engineers:

1) ASME A112.6.1 - Floor-Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use.
2) ASME A112.18.1 - Plumbing Fixture Fittings.
3) ASME A112.19.1M - Enameled Cast Iron Plumbing Fixtures.
4) ASME A112.19.2M - Vitreous China Plumbing Fixtures.
5) ASME A112.19.3 - Stainless Steel Plumbing Fixtures (Designed for Residential Use).
6) ASME A112.19.4 - Porcelain Enameled Formed Steel Plumbing Fixtures.
7) ASME A112.19.5 - Trim for Water-Closet Bowls, Tanks and Urinals.

4. SUBMITTALS

a. Section 013300 - Submittal Procedures: Submittal procedures.

b. Product Data: Submit catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

c. Manufacturer's Installation Instructions: Submit installation methods and procedures.

d. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

5. SUSTAINABLE DESIGN SUBMITTALS

a. Section 018113 - Sustainable Design Requirements: Requirements for sustainable design submittals.

b. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.

1) Water Efficiency Certificates:

a) Certify plumbing fixture flow rates.

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6. CLOSEOUT SUBMITTALS

a. Section 017000 - Execution and Closeout Requirements: Closeout procedures.

b. Operation and Maintenance Data: Submit fixture, trim, exploded view, and replacement parts lists.

7. QUALITY ASSURANCE

a. Provide products requiring electrical connections listed and classified by UL as suitable for purpose specified and indicated.

b. Provide plumbing fixture fittings according to ASME A112.18.1 that prevent backflow from fixture into water distribution system.

c. Maintain one copy of each document on Site.

8. QUALIFICATIONS

a. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.

b. Installer: Company specializing in performing Work of this Section with minimum of three years' experience and approved by manufacturer.

9. DELIVERY, STORAGE, AND HANDLING

a. Section 016000 - Product Requirements: Product storage and handling requirements.

b. Accept fixtures on Site in factory packaging. Inspect for damage.

c. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

10. WARRANTY

a. Section 017000 - Execution and Closeout Requirements: Product warranties and product bonds.

b. Furnish five year manufacturer warranty for plumbing fixtures.

11. EXTRA MATERIALS

a. Section 017000 - Execution and Closeout Requirements: Spare parts and maintenance products.

b. Furnish two sets of faucet washers, flush valve service kits, lavatory supply fittings, shower heads and toilet seats.

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PART 2 – PRODUCTS

Correctional Fixture Combo Unit = CFC
Correctional Fixture Shower Unit = CFSH
Combo Unit = Combination Toilet & Lavatory

FIXTURES BY THE PLUMBING CONTRACTOR.

2.1 **Correctional Fixture (CFC-1), Lavatory/Water Closet Combination (furnished and installed by Plumbing Contractor.):** Willoughby #ECW-1546-x-ON, on floor, rear access, cabinet fabricated of 14 gauge (14 gauge top) type 304 stainless steel, 2" ball pass, 1.28 gpf blowout style design, self-draining flushing rim and electronic controls. See plans for configuration.

1. Fixture Configuration:
   a. ECW, wall outlet
   b. -1546, 15" lav.-toilet combination
   c. -x, See plans for toilet configuration
   d. -ON, on-floor mounting
   e. -BPH, penal bubbler/filler
   f. -1.28 GPF
   g. -E1L2 dual temp, electronic W/PZPB, Piezo pushbutton
   h. -EB, elbow lavatory waste
   i. -LW1, brass through wall lav waste and p-trap assembly
   j. -TWE, toilet waste extension
   k. -TWC4P, toilet waste Coupling for 4" PVC
   l. -TW5P, 4" PVC clean-out tee
   m. -PC4, pinned PVC cleanout plug-4"
   n. -ET4 – Electronic toilet over-flow preventer.
   o. -RTH recessed tissue holder
   p. -WS, wall sleeve
   q. -FVT, flush valve connection
   r. -EFVP - electronic W/PZPB, Piezo pushbutton
   s. -TSC, toilet shipping cover

2. Flush Valve: Sloan Regal 9603-1.28

2.2 **Correctional Fixture (CFC-2), Lavatory/Water Closet Combination, ADA, Front Access Handicap Accessible (furnished and installed by Plumbing Contractor):** Willoughby #ECW-4896-x-ON-FA, On floor, **FRONT** access, cabinet fabricated of 14 gauge (14 gauge top) type 304 stainless steel, 2" ball pass, 1.28 gpf blowout style design, self-draining flushing rim and electronic controls. See plans for configuration.

1. Figure configuration:
   a. ECW, wall outlet
   b. -4896, 48" lav.-toilet combination, ADA
   c. -x, See plans for toilet configuration
   d. -ON, on-floor mounting
   e. -DMBH, ligature-resistant bubbler/filler - deck mounted

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f. -1.28 GPF
g. - E1L2 dual temp, electronic W/PZPB, Piezo pushbutton
h. -EB, elbow lavatory waste
i. -LW1, brass through wall lav waste and p-Trap assembly
j. -TWE, toilet waste extension
k. -TWC4P, toilet waste coupling for 4" PVC
l. -TW5P, 4" PVC clean-out tee
m. -PC4, pinned clean-out plug PVC -4"
n. -ET4 – Electronic toilet over-flow preventer.
o. -WS, wall sleeve
p. -FVT, flush valve connection
q. -EFVP - electronic flush valves W/PZPB, Piezo pushbutton
r. -TSC

2. Flush Valve: Sloan Regal 9603-1.28

2.3 **Correctional Fixture (CFC-3), Lavatory/Water Closet Combination, ADA, Rear Access Handicap Accessible (furnished and installed by Plumbing Contractor):** Willoughby #ECW-4896-x-ON-FA, On floor, Front access, cabinet fabricated of 14 gauge (14 gauge top) type 304 stainless steel, 2" ball pass, 1.28 gpf blowout style design, self-draining flushing rim and electronic controls. See plans for configuration.

1. Figure configuration:
a. ECW, wall outlet
b. -4896, 48" lav.-toilet combination, ADA
c. -x, See plans for toilet configuration
d. -ON, on-floor mounting
e. -DMBH, ligature-resistant bubbler/filler - deck mounted
f. -1.28 GPF
g. - E1L2 dual temp, electronic W/PZPB, Piezo pushbutton
h. -EB, elbow lavatory waste
i. -LW1, brass through wall lav waste and p-Trap assembly
j. -TWE, toilet waste extension
k. -TWC4P, toilet waste coupling for 4" PVC
l. -TW5P, 4" PVC clean-out tee
m. -PC4, pinned clean-out plug PVC -4"
n. -ET4 – Electronic toilet over-flow preventer.
o. -WS, wall sleeve
p. -FVT, flush valve connection
q. -EFVP - electronic flush valves W/PZPB, Piezo pushbutton
r. -TSC

2. Flush Valve: Sloan Regal 9603-1.28

2.4 **Correctional Fixture (CFC-4), Lavatory/Water Closet Combination Ligature Resistant, (furnished and installed by Plumbing Contractor.):** Willoughby #ECW-1806-x-ON, on floor, **REAR ACCESS**, cabinet fabricated of 14 gauge (14 gauge top) type 304 stainless steel, 2" ball pass, 1.28 gpf blowout style design, self-draining flushing rim, bowl skirt and electronic controls. See plans for configuration.

1. Figure configuration:
a. ECW, wall outlet

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b. -1806, 18" lav-toilet combination
c. -x, See plans for toilet configuration
d. -ON, on-floor mounting
e. -BP, penal bubbler/filler
f. -1.28 GPF
g. -PML2, PBH dual temp. pneumatic metering lavatory valve
h. -EB, elbow lavatory waste
i. -LW1, brass through wall lav waste and p-trap assembly
j. -TWE, toilet waste extension
k. -TWC3C, toilet waste Coupling for 3" Cast Iron
k. -TW3, 4" cast iron clean-out tee
l. -PCB3, pinned brass cleanout plug-4"
m. -T4, toilet overflow preventer, manual reset
n. -RTH recessed tissue holder
n. -WS, wall sleeve
o. -FVT, flush valve connection
p. -FV, flush valve
q. Bowl Skirt

2. Flush Valve: Sloan Regal 9603-1.28

2.5 **Correctional Fixture (DT-1), Detox Toilet: (furnished and installed by Plumbing Contractor)** Willoughby #FD-1400-LFL-FV-3.5-RFVB-HB8156. 14 Ga. Type 304 stainless steel construction, with exposed surfaces polished to #4 finish and the interior surfaces glass blasted. 14" diameter top with 7-gauge stainless steel top grate. Flushing rim with positive after-fill. 3 ½" seal and 2 5/8" diameter trap. Contractor shall route 1" water supply line down thru masonry wall and below floor slab from wall mounted flush valve to toilet. Flush Valve: To be installed in remote stainless steel wall box Willoughby # RFVB with bottom of box at + 48" A.F.F.

1. Figure configuration:
   a. FD-1400-LFL, blowout, less flange
   b. -FV, Flush valve, Sloan 110 HCL
   c. -LFL, less flange
   d. -3.5 GPF
   d. -RFVB, remote flush valve with box
   e. -HB-8156, hose box

2.6 **Correctional Fixture (CFSH-1), Shower Cabinet – ADA Compliant (Furnished and Installed by Plumbing Contractor):** US-3636HC-FA-L/R-E1L1-MA2-PZPB-1.5gpm-CSH-2HD-ICD-CP-CHV-TF-GBC-RD; **FRONT ACCESS** stainless steel security ADA Compliant shower cabinet, constructed of 14 gauge, type 304 stainless steel and electronic controls.

a. US-3636-HC-FA- 36"x36" Handicap, Front Access
b. L/R- Left Hand or Right Hand Pushbutton Orientation
c. E1L1-MA2- Single Temp. Electronic Manifold
d. PZPB- Ligature resistant Piezo Pushbutton

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e. 1.5GPM- 1.5 Gallon Per Minute Flow Rate.
f. CSH-Ligature resistant shower head.
g. 2HD/ICD- Inside Caulk Cabinet Shower Drain
h. -Two fixed shower heads
i. CP-CHV-TF- Horizontal Closure Panel Recessed Configuration - Contractor to provide dimensions to manufacturer for quote and build
j. GBC- Grab Bar Closure Plate
k. RD- Recessed soap dish

2.7 **Correctional Fixture (CFSH-2), Shower Cabinet (Furnished and Installed by Plumbing Contractor):**
US-3636HC-FA-L/R-E1L1-MA2-PZPB-1.5gpm-CSH-ICD-CP-CHV-TF-GBC-RD; **FRONT ACCESS** stainless steel security ADA Compliant shower cabinet, constructed of 14 gauge, type 304 stainless steel and pneumatic controls.

a. US-3636-HC-FA- 36"x36" Handicap, Front Access
b. L/R- Left Hand or Right Hand Pushbutton Orientation
c. E1L1-MA2- Single Temp. Electronic Manifold
d. PZPB- Ligature resistant Piezo Pushbutton
e. 1.5GPM- 1.5 Gallon Per Minute Flow Rate.
f. CSH-Ligature resistant shower head.
g. ICD- Inside Caulk Cabinet Shower Drain
h. One fixed position (corner mounted) shower head
i. RD- Recessed soap dish

Correctional Fixture Combo Unit = CFC
Correctional Fixture Shower Unit = CFSH
Combo Unit = Combination Toilet & Lavatory

FIXTURES BY THE CELL MANUFACTURER.

2.8 **Correctional Fixture (CFC-5), Lavatory/Water Closet Combination, ADA, Handicap Accessible, (furnished and installed by Cell Manufacturer) <u>Valves, loose plumbing accessories and fittings will be furnished and received by cell manufacturer, but installed by plumbing contractor:</u>**
Willoughby #ECW-4896-x-ON, On floor, **REAR ACCESS**, cabinet fabricated of 14 gauge (14 gauge top) type 304 stainless steel, 2" ball pass, 1.28 gpf blowout style design, self-draining flushing rim and electronic controls. See plans for configuration.

1. Figure configuration:
   a. ECW, wall outlet
   b. -4896, 48" lav-toilet combination, ADA
   c. -x, See plans for toilet configuration
   d. -ON, on-floor mounting
   e. -DMBH, ligature-resistant bubbler/filler - deck mounted
   f. -1.28 GPF

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g. -E1L2 dual temp, electronic W/PZPB, Piezo pushbutton
h. -EB, elbow lavatory waste
i. -LW1, brass through wall lav waste and p-Trap assembly
j. -TWE, toilet waste extension
k. -TWC4P, toilet waste coupling for 4" PVC
l. -TW5P, 4" PVC clean-out tee
m. -PC4, pinned clean-out plug - 4"PVC
n. -ET4 – Electronic toilet over-flow preventer.
o. -TFE, flush valve extension
p. -EFVP, flush valve - electronic flush valve w/ PZPB, Piezo pushbutton
q. -TSC, toilet shipping cover

2. Flush Valve: Sloan Regal 9603-1.28
3. Use "-RTH2" for separate in-wall recessed tissue holder

2.9 **Correctional Fixture (CFC-6), Lavatory/Water Closet Combination (Fixture and pushbuttons furnished and installed by Cell Manufacturer). Valves, loose plumbing accessories and fittings will be furnished and received by cell manufacturer, but installed by plumbing contractor:** Willoughby ECW-1546-x-ON, On floor, **REAR ACCESS**, cabinet fabricated of 14 gauge (14 gauge top) type 304 stainless steel, 2" ball pass, 1.28 gpf blowout style design, self-draining flushing rim and electronic controls. See plans for configuration:

Fixture Configuration:
a. ECW, wall outlet
b. -1546, 15" lav.-toilet combination
c. -x, See plans for toilet configuration
d. -ON, on-floor mounting
e. -BPH, penal bubbler/filler
f. -1.28 GPF
g. -E1L2 dual temp, electronic W/PZPB, Piezo pushbutton
h. -EB, elbow lavatory waste
i. -LW1, brass through wall lav waste and p-trap assembly
j. -TWE, toilet waste extension
k. -TWC4P, toilet waste Coupling for 4" PVC
l. -TW5P, 4" PVC clean-out tee
m. -PC4, pinned PVC cleanout plug-4"
n. -ET4 – Electronic toilet over-flow preventer.
o. -RTH recessed tissue holder
p. -WS, wall sleeve
q. -FVT, flush valve connection
r. -EFVP - electronic W/PZPB, Piezo pushbutton
s. -TSC, toilet shipping cover

2. Flush Valve: Sloan Regal 9603-1.28

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2.10 **Correctional Fixture (CFSH-3), Cell Shower Assembly – ADA, Handicap Accessible (To Be Constructed By Cell Manufacturer As Part Of The Cell) (Showerheads and Pushbuttons to be furnished and installed by Cell Manufacturer) – Valves, loose plumbing accessories and fittings will be furnished and received by cell manufacturer, but installed by plumbing contractor:**

1. The following components shall be provided as part of the construction of the individual cell showers by the cell manufacturer. Component installation shall be vandal resistant, but yet accessible for service.
2. Shower heads shall be located within the shower cabinet in such a manner that the spray pattern will not be directed toward the entry side of the cabinet.
3. Shower assembly shall be in compliance with ADA.
   a. Various components will be provided as part of the construction of the individual cell showers. Component installation shall be vandal resistant, but yet accessible for service.
   b. Shower head will be located in shower compartment ceiling
   c. Floor shall have a slip resistant surface.

   Components shall include:
   a. One single temperature electronic shower valve Willoughby #E1L1--1.5 (installed by plumbing contractor)
   b. One ligature resistant Piezo pushbutton assembly Willoughby #PZPB. (installed by cell manufacturer)
   c. One ligature resistant ceiling mounted shower head Willoughby #CMSH (installed by cell manufacturer)
   e. Tubing shall be routed in a conduit (of sufficient size to allow removal and replacement) inside of the fixture wall. Conduit shall be accessible from rear service chase.
5. Submit shop drawings and product data sheets to the Architect/Engineer for review and approval, prior to commencing fabrication.

2.11 **Correctional Fixture (CFSH-4), Cell Shower Assembly (To Be Constructed By Cell Manufacturer As Part Of The Cell) (Showerheads and Pushbuttons to be furnished and installed by cell manufacturer) - Valves, loose plumbing accessories and fittings will be furnished and received by cell manufacturer, but installed by plumbing contractor:**

1. See Architectural Documents for construction and configuration of the shower assembly by Div. 11 Cell Manufacturer and the Plumbing Drawings for details regarding rough-in, trap and final connections.
   a. Various components will be provided as part of the construction of the individual cell showers. Component installation shall be vandal resistant, but yet accessible for service.
   b. Shower head will be located in shower compartment ceiling
   c. Floor shall have a slip resistant surface.
2. Components shall include:
   a. One single temperature pneumatic shower valve Willoughby #PML1-1.5 (installed by plumbing contractor)
   b. One ligature resistant pushbutton assembly Willoughby #PBH. (installed by cell manufacturer)
   c. One ligature resistant ceiling mounted shower head Willoughby #CMSH (installed by cell manufacturer)

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3. Submit shop drawings and product data sheets to the Architect/Engineer for review and approval, prior to commencing fabrication.

PART 3 – EXECUTION

3.01 EXAMINATION

a. Section 013000 - Administrative Requirements: Coordination and project conditions.

b. Verify walls and floor finishes are prepared and ready for installation of fixtures.

c. Verify electric power is available and of correct characteristics.

3.02 PREPARATION

A. Rough-in fixture piping connections according to minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.02 INSTALLATION

a. Install components level and plumb.

b. Install each fixture with trap, easily removable for servicing and cleaning.

c. Install and secure fixtures in place with wall supports or carriers.

d. Seal fixtures to wall and floor surfaces with vandal resistant sealant as specified in this section.

e. Install each fixture with trap, easily removable for servicing and cleaning.

f. All lavatory traps shall have an integral cleanout plug.

g. Hot water to fixtures shall not exceed 105 degrees.

h. The Plumbing Contractor shall furnish and install all waste connections, cleanout pins, hooks and traps located in the service chase area.

i. The Plumbing Contractor shall coordinate ADA shower trench drain location with Cell Manufacturer.

j. Shower Traps: The Plumbing Contractor may be required to saw-cut the concrete floor in order to install the required shower P-Trap in the chase area.

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3.03 INTERFACE WITH OTHER PRODUCTS

A. Drain Locations. Plumbing Contractor to confirm location and size of fixtures outlets and drains with the Cell Manufacturer.

3.04 ADJUSTING

a. Section 017000 - Execution and Closeout Requirements: Testing, adjusting, and balancing.

b. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.05 CLEANING

a. Section 017000 - Execution and Closeout Requirements: Final cleaning.

b. Clean plumbing fixtures and equipment.

3.06 PROTECTION OF INSTALLED CONSTRUCTION

a. Section 017000 - Execution and Closeout Requirements: Protecting installed construction.

b. Do not permit use of fixtures before final acceptance.

c. Contractor shall protect plumbing fixtures from damage, dents, scratches and abuse while fixtures are on project site. Fixtures that are found to be damaged **shall be replaced** by the Plumbing Contractor at no additional cost to the owner.

END OF SECTION 22 46 00

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SECTION 22 46 05

WATER MANAGEMENT SYSTEM

PART 1 - GENERAL

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.

2. SUMMARY

a. Section Includes:

1) Combination units.
2) Water closets.
3) Flushometer valves.
4) Lavatories.
5) Showers
6) Electronic Controls.

b. Related Requirements:

1) Section 224213.13 "Commercial Water Closets."
2) Section 224213.16 "Commercial Urinals."
3) Section 224216.13 "Commercial Lavatories."
4) Section 224216.16 "Commercial Sinks."
5) Section 224223 "Commercial Showers."
6) Section 224233 "Wash Fountains."
7) Section 224300 "Healthcare Plumbing Fixtures."
8) Section 224500 "Emergency Plumbing Fixtures" for emergency showers.
9) Section 224713 "Drinking Fountains" for standard drinking fountains.

3. DEFINITIONS

a. Accessible Service Space: Service area in secure space behind wall-mounted fixtures.

b. Rear-Access Fixture: Security plumbing fixture designed to mount through wall, so installation and removal of fixture, piping, and other components are accessible only from service space behind wall.

c. Front-Access Fixture: Security plumbing fixture designed to mount to wall with installation and removal from fixture side of wall, and with piping and other components accessible only from access panel(s) in fixture.

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4. ACTION SUBMITTALS

a. Product Data: For each type of product.

1) Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for security plumbing fixtures.
2) Include rated capacities, operating characteristics, and furnished specialties and accessories.

5. CLOSEOUT SUBMITTALS

a. Maintenance Data: For security plumbing fixtures and components to include in maintenance manuals.

PRODUCTS

6. ELECTRONIC CONTROLS

a. Electronic Controls: Electronic Networked Water Management System.

1) Basis-of-Design Product: Subject to compliance with requirements, provide:

Willoughby Industries; WMSII, to electronically control fixtures in the Security Center POD Addition.

2) Description:

a) Water Management System: PC-based server (operator workstation) running on Windows 8 or newer operating system. Network communications shall be CAN-bus based providing proactive, prioritized communications of status of controller inputs/activities to operator workstation. Polling-type networks shall not be permitted. PC shall serve as the operator interface serving single or multiple individual trunks of networked Cell Valve Controllers (CVC's). The PC operator workstation shall display all fixtures and indicate their operation and state graphically. PC shall be equipped with:

(1) Monitor: 19 inch or larger with HD resolution of 1366 by 768 pixels minimum.
(2) Touchscreen Monitor:
(3) RAM: 4 GB minimum.
(4) Hard Drive: 64 GB minimum.
(5) Wireless keyboard.
(6) Wireless mouse.
(7) USB Ports: 4 minimum.
(8) CAN-bus interface device(s) for network communication to Cell Valve Controllers (CVC's).

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(9) Water Management Software: Installed on PC, configured, and tested prior to installation to provide control and monitoring of security plumbing fixtures flush valves, lavatory valves, and shower valves connected to the CAN-bus networked control system.

b) WMS II operator workstation shall be located where indicated on the drawings.

c) Screen Graphics: Floor Plan Screen Layout. Layout information (areas and cell numbers and fixtures controlled by networked system) shall be supplied to system supplier in DWG file format. Based on information supplied:

(1) Level 1 screen shall:

(a) Display top-level layout of defined sections of the facility.
(b) Provide selected areas identified by shape, color, and label to link Level 1 screen to Level 2 screens with enlarged details and fixtures of individual facility sections.

(2) Level 2 screens shall:

(a) Provide magnified detail and fixture icons.
(b) Provide identification of each fixture by location on the screen layout, icon type, and labeling (e.g., cell number of its location).
(c) It shall be acceptable to use only a Level 1 screen if all fixtures can be displayed legibly and logically by functional area on one screen.
(d) Provide graphical indication of fixture status.

d) Individual microprocessor-driven Cell Valve Controllers (CVCs) shall be located in the plumbing chase(s) and shall control the operation of electronic laboratory valves, electronic shower valves, electronic drinking fountain valves, and electronic-hydraulic flush valves. An option shall also be available to control the operation of master shut-off valve(s) that provide(s) water to an area of several cells or fixtures.

e) CVC's shall require 24 volts AC for operation. System manufacturer shall supply 120/24 VAC step-down transformers for each CVC supplied. Transformers shall be UL Class 2, overload protected.

f) Each CVC shall be capable of controlling up to 2 lavatory/toilet combination units (1 hot valve, 1 cold valve, and 1 flush valve for each combination unit), 3 individual lavatories, or up to 4 toilets with overflow sensing (6 toilets without overflow sensing), or combinations thereof up to a total of 6 individual low-voltage solenoid valves. CVC's shall be modular and capable of operating in a fully networked or stand-alone configuration.

g) Valve output LEDs on the CVC shall provide the status of all valve outputs. An additional set of status LEDs shall indicate the presence and type of any inhibit or lockout condition on valve function.

h) Diagnostic LEDs: Provided on CVC to indicate the presence of incoming AC control power, that the CVC is operational, communication status, and input status.

(1) HB LED (heartbeat): Flashes to show controller is not only powered, but that the program in the controller is running. It flashes on and off.
(2) COM LED: Indicating when there is network communications activity occurring.

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(3) ERR LED: Indicating a communication error occurred.
(4) IN LED: Indicating one of the input switches is closed. (It can be used to diagnose input switch problems.)

i) Diagnostic pushbuttons on the CVC shall be provided to enable maintenance personnel to manually activate valves and overflow functions from the controller in the plumbing chase.
j) Valve activation shall come from vandal-resistant stainless steel internally sealed pushbuttons.

(1) Pushbuttons shall require less than 5 lbf to activate.
(2) Pushbutton housings shall be electrically isolated from system voltages.

k) All solenoid valves shall be non-hold open (normally closed), but all metering times shall be independently adjustable.

(1) Metering time shall be:

(a) Adjustable from one (1) to sixty (60) seconds for each lavatory valve.
(b) Adjustable from one (1) to ten (10) seconds for each flush valve.
(c) Adjustable from one (1) second to nine (9) minutes and fifty-nine (59) seconds for each shower valve.

(2) Metering cycles shall be interruptible with a second pushbutton.
(3) All settings shall be settable for a single fixture or a group selection of all fixtures of the same type on the PC screen.

l) Each controller shall be programmed at the factory to the following settings:

(1) Lavatory Valve Cycle: Fifteen (15) seconds hot water run time, fifteen (15) seconds cold water run time.

(2) Flush Valve Cycle (Water Closets and Urinals): Two (2) seconds on time.

(3) Shower: Upon initiation, two (2) minute run time. If the user finishes the shower before the two (2) minute period, user may press pushbutton to terminate the cycle. Pressing the pushbutton during the run time shall not extend the cycle.

m) A programmable re-initiate delay feature function (toilets, urinals, lavatories, showers, and drinking fountains) shall be provided to control their amount of use to a preset threshold, after which the function will be locked out for a preset period of time of up to four hours.
n) A programmable initiate delay feature for the fixture function (toilets, urinals, lavatories, showers, and drinking fountains) shall be provided to enable a timed delay between the pushbutton switch activation and the subsequent valve activation.
o) System shall provide overuse control consisting of:
(1) Individual toilet, urinal, lavatory, shower, and drinking fountain use limits.
(2) Programmable response to overuse condition of notification at the operator workstation, latched lockout of fixture, or auto-limit of fixture operation to

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prevent its overuse. All overuse notifications shall appear on the operator workstation.

(3) Configurable overuse limitation to a given number (adjustable) of valve actuations for flushing devices or a given amount of cycle-on time (adjustable) for showers, lavatories, and drinking fountains within a given time period (adjustable) of up to 24 hours.

(4) Concurrent operation with other use-control features of the system.

p) The operator workstation shall be capable of networks of up to 508 CVC nodes and up to 3,048 valves.

q) Network Wiring: Twisted 3-pair cable of CAT 3 rating shall be used for all network wiring (provided by others). Installer shall follow system manufacturer's instructions for installation and verification testing. Each network shall not exceed 4,000 feet in total length from operator workstation to the last CVC in the network string.

r) In the event of a loss of network communications or loss of power, system timing parameters shall be retained in each CVC to allow fixtures to operate in the same way that they operated prior to the loss of power or the loss of network communications.

s) Input/Output Ports Cabling:

(1) Each input/output shall be clearly identified by the use of harness location, color coding of wires, gender of connectors 1/4 inch fully insulated male tab connections for inputs and 1/4 inch fully insulated female tabs for outputs), and supplied documentation.

(2) All input/output cables shall be supplied with cables attached to the CVC and only outboard switch and valve connections to be plugged in by installer.

(3) Supplied valve and switch cabling from the CVC control board shall each be 8 feet with the option to add extensions if necessary.

t) The networked system shale be capable of:

(1) Enabling or disabling an individual fixture or an entire group of fixtures from the operator workstation.

(2) Controlling the maximum number of simultaneous flushes (adjustable from 1 to 999) that can occur within a given time period (adjustable from 1 to 60 seconds).

(3) Automatically flushing a toilet or actuating a non-flushing fixture after an adjustable period of non-use has passed to prevent drying out or creating stagnate water.

(4) Allowing for remote actuation of fixtures from the operator workstation.

(5) Providing ability from the operator station to dynamically lock or reset (unlock) a fixture.

(6) Providing up to 4 scheduled permit time periods per day and week for selected fixtures.

(7) Providing indication and reset capability of overflow alarms.

(8) Logging of time, date, and function of all valve activity chronologically, including:

(a) On and off times of each fixture function.

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(b) Lockout times.
(c) Network status changes by node.

u) The networked system shall provide 4 levels of security accessed via user name and password depending on system settings (Each level includes the functions of the previous lower level).

(1) View-only Security Level:

(a) Move between display screens.
(b) Observe fixture activity on screens.
(c) Observe any loss of communications to fixture controllers.
(d) Log into a higher-security level.

(2) Operator Security Level:

(a) Remote valve actuation.
(b) Fixture lockout/reset.
(c) Clear alarms (overflow and overuse).

(3) Supervisor Security Level:

(a) Set and adjust valve timing.
(b) Set and adjust initiate and re-initiate delays.
(c) Set and adjust permit (lockout) schedules.
(d) Set and adjust overuse limits and responses.
(e) Set alarm display options.
(f) Enable/disable and set FlushGuard to limit simultaneous flushes.
(g) Access fixture event log (if enabled by administrator).
(h) Use log files to analyze water-consumption history.
(i) Enable and disable sound effects.
(j) Access system user activity log files (if enabled by administrator).
(k) Optional selection of a 24-hour point at which all overuse counts will be reset.

(4) Administrator Security Level:

(a) Create system user accounts with user name, password, and security level defined.
(b) Set and adjust network communications settings.
(c) Enable and configure remote client connections to server.
(d) Configure fixture event log files and user activity log files.
(e) Set sound files to be used when sound feature is enabled.

v) Client-server Networking System shall be capable of linking client sessions on other Windows-based PCs to the main server via an Ethernet network. Control and monitor functions possible on the central operator station may be performed on a client PC based on user security level.

(1) Server will be located where indicated on drawings.

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(2) Water management software shall be installed, configured, and verified by system integrator with assistance from water management software supplier.

w) Solenoids compatible with voltage, power, and mating connections of the outputs of the CVC.
x) Supply shut off valve: One valve for each water supply.
y) Controller (CVC) Housing: Water resistant enclosure.

EXECUTION

7. 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.

d. Electrical power (120v.) will be provided at the rear of each cell by the Electrical Contractor.

e. The Water Management supplier shall provide and install the transformer (on rear of cell) required to power the fixture devices.

f. Network wiring "provided by others" shall be installed and tested per the plumbing control system supplier's instructions.

END OF SECTION 22 46 05

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SECTION 23 00 00 - HVAC GENERAL REQUIREMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the general requirements applicable to all Heating, Ventilation, and Air Conditioning work.

B. Provide complete and fully operational HVAC systems controlled as indicated in the construction documentation.

C. The construction documents are comprised of both specifications and construction drawings. Information pertinent to design intent may be included in either or both locations, which create one set of contract documents.

1.2 DEFINITIONS

A. Basis of Design: Equipment and materials identified in the drawing schedules, notes, and specifications and identified as a specific product or example represents the intended Basis of Design. Any equipment or materials provided by the Contractor must meet or exceed the performance quality of the Basis of Design.

B. Substitution: Any equipment or material which is not the Basis of Design.

C. General Requirements: The provisions set forth in the Division 01 sections apply to the entire work of the contract and other elements which are included in the project. Basic contract definitions are in the General Conditions.

D. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels generally considered normally occupiable by people.

E. Exposed, Interior Installations: Installed indoors and exposed to viewing by people. Examples included finished spaces and mechanical rooms equipment rooms.

F. Exposed, Exterior Installations: Exposed to view but outside the building envelope and therefore exposed to weather and ambient conditions. Examples include roof top locations.

G. Concealed, Interior Installations: Installed within the building envelope, but concealed from view. Examples include those items installed within walls, above ceilings, below floors, or in chases.

H. Concealed, Exterior Installations: Installed outside of the building envelope, but concealed from view and protected from weather conditions by a secondary structure, but subject to outdoor ambient conditions. Examples include installations within enclosures that are not heated or cooled.

I. Indicated: Implication of a cross reference to a graphic representation, note, schedules, or other specification section or another area within the contract documents. The terms “shown”, “noted”,

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"scheduled", and "specified" are used as synonyms to "indicated". No limitation of cross reference location is intended except as specifically noted.

J. Furnish: Supply and deliver to project site, ready for unloading, unpacking, assembly, installation and similar operations. Where "furnish" applies to work for which the installation is not otherwise specified, "furnish" shall mean "furnish and install".

K. Install: Operations at the project site including "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operation.

L. Provide: To furnish and install complete and ready for intended use.

1.3 SUBMITTALS

A. Action Submittals: These submittals are required to be returned with no exceptions prior to procuring or installing products or materials. The Submittal Review process is described in Section 01.

1. Work Plans: Written Narrative of the work plan used to create the schedule. Coordinate with other trades and contractors to develop required work plans as required to develop the long term coordinated construction schedule.
2. Product Data: Providing information on the actual product selection intended for use as specified in other Division 23 Specifications and the Construction Documents. All product data submittals shall clearly identify the product to be used subject to rejection.
3. Shop Drawings: Providing information on the actual installation methodology to be used to install items as specified in other Division 23 Specifications and the Construction Documents

B. Informational Submittals: These submittals are intended to facilitate coordination and construction phasing and scheduling. These submittals will not be returned unless non-conformance with the contract documents is noted.

1. Construction Schedules: Schedule of work showing percent completion of milestones in the work plan. Coordinate with the general contractor, owner, or owner's representative, to develop, maintain, and regularly update the construction schedule as required
2. Coordination Documents: Drawings including Plans, Sections, Elevations, localized infrastructure crossing details, drawn to scale, on which the items below have been included utilizing information from all trades, contractors, and installers:
    a. Building Structure and structural supports and attachments for piping, ductwork, lighting fixtures, cables, cable trays, raceways and conduit.
    b. Building Roofs, walls, floors, windows, doors, and ceilings
    c. Suspended Ceilings components
    d. HVAC Equipment, piping, ductwork, controls devices, and associated electrical disconnects.
    e. Size and Location of access doors and panels required for maintenance of products installed in walls and inaccessible ceilings.
    f. Size and Location of penetrations through the finished floor.
    g. Size and Location of penetrations through fire rated walls.
    h. Items penetrating the finished ceiling, including but not limited to:
        1) Air outlets and inlets

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2) Luminaires
3) Fire Suppression Sprinklers
4) Fire Alarm Components, such as horns and strobes
5) Life Safety Components, such as exit signs
6) Mass Notification Components, such as speakers
7) IT components, such as routers
8) Security components, such as cameras
9) Service Access Panels

C. Substantial Completion Submittals: These submittals are required prior to achieving substantial completion from the Architect or Engineer of Record. One hard copy shall be turned over to the Owner's Maintenance Staff at Owner Training.

1. Record Drawings Submittal reviewed with "No Exceptions" by Architect and/or Engineer of record.
2. Commissioning Documentation as required by other specification sections provided in .PDF file format on a USB Thumb-drive and one printed copy organized by specification section in multiple three ring binders not to exceed 4", including at minimum:
    a. Start Up Reports for all HVAC Equipment and components.
    b. Testing, Adjusting and Balancing report returned with "No Exceptions" by the Architect and/or Engineer of record.
    c. Manufacturer's Operation and Maintenance Data for all HVAC system Products, including all accessory sizes required, such as belt and filter sizes and types.
    d. Emergency Service Contact including Name, email address, and Phone Number.
    e. Written Record from Owner stating Owner's Representative system training has been successfully delivered.
3. Service Valve Tag Chart and Location Maps.
4. Updated Control Valve Schedule.
5. Field Reports indicating successfully completing Ductwork Leakage Testing.
6. Field Reports indicating successfully completing Piping Pressure Testing.
7. Any and all maintenance required items as specified in other Division 23 Sections in packages with protective cover for storage and identified with labels describing contents and intended use. (i.e. FAN BELT – AHU-1 SUPPLY FAN)

1.4 DELIVERY, STORAGE, AND HANDLING

A. Where feasible, arrange for product delivery to the construction site when construction has progressed to allow for delivery to the final installed location protected from the weather and site security is sufficient to prevent easy theft (lockable door, container, or cage area and/or a night guard).

B. Deliver all pipes with factory applied end caps. Caps shall be maintained through shipping and storage until such time pipe is being installed to prevent entrapment of debris and contaminants and minimize pre-construction corrosion of materials.

C. Do not allow any materials to be stored exposed to weather, standing water, excessive dirt and dust, or in a manner to prevent the flow of traffic through the worksite.

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D. Handle all products with care and per manufacturer's written instructions for lifting and rigging. Do not install damaged items without written consent from the Owner.

1.5 COORDINATION

A. The drawings indicate the general arrangement, routing, and scope of the systems and are to be followed as often as possible. Deviations form the drawn layout are permissible, if necessitated by field conditions and approved by the Architect or Engineer of Record through submittal and properly coordinated with all other trades.

B. The drawings are not intended to show every minor vertical and/or horizontal offset required to navigate a complete installation of the system due to obstructions that may arise due to field conditions. Contractors shall anticipate potential additional offsets in their construction proposals.

C. The drawings, schedules, and specifications shall be considered one cooperative document. Items may or may not appear in both drawings and specifications. Anything appearing in one or the other location shall be considered included in the contract documents and the contractor shall provide a bid based inclusive of both Specifications and Drawings. Any and all identified conflicting statements between the Specifications and Drawings that affects the final bid price shall be submitted for clarification during the bidding process.

D. New Equipment: All equipment provided by the contractor shall be provided as "new" and not "used". Contractor shall not energize equipment prior to substantial completion unless:

    a. Factory Representative and/or Owner's Representative is in attendance for start-up testing.
    b. The Test, Adjusting and Balancing Contractor is actively testing the equipment
    c. Specific, written authorization from the Owner has been granted for:
        i. Space Pressurization in conjunction with approved pressurization plan.
        ii. Space Tempering during finish installation.

E. Contractor shall field verify all measurements in the field and shall be responsible for the correct fitting of all systems and components. Contractor shall coordinate all work with other branches and trades to minimize conflict and delays. Contractors shall:

    a. Coordinate work plan in advance with all other trades and immediately upon discovery, report any anticipated difficulty with proposed resolutions to the general contractor and/or Architect or Engineer of Record.

    b. Provide the General Contractor and Owner with a detailed schedule to be incorporated within the overall construction schedule to include at minimum:

        i. Any necessary demolition, as phased by floor and area.
        ii. Temporary Construction as required to maintain any existing services.
        iii. Coordination Efforts
        iv. Architectural Rough Ins – i.e. wall and floor sleeves installation.
        v. Product Submittals
        vi. Shop Drawing Submittals
        vii. Product Procurement and storage
        viii. Product Installation

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ix. Duct and Piping Installation
x. Installation of Insulation and Identification Systems
xi. Start-Up and Commissioning of Equipment
xii. Owner Training
xiii. Punch List Inspection
xiv. Substantial Completion

c. Coordinate space needs of ductwork, piping, chases, wall, floor, and roof penetrations, with other trades during construction to allow for easy installation.

d. Coordinate installation of all structural supporting elements, sleeves, sleeve seals, etc. through cast-in-place concreate and other structural components as they are constructed.

e. Coordinate requirements for all access hatches, panels, doors, hand holes for HVAC items during work planning for wall and ceiling construction. Access panels and doors are specified in Division 08.

f. Coordinate any and all trenching, excavating, bedding, and backfilling with general contractor and appropriate piping specifications and earthwork specifications in other divisions.

g. Coordinate any HVAC Demolition with all aspects of demolition and temporary construction by other trades, including dust barriers and electrical demolition. Do not remove electrical components of HVAC equipment without electrical components first being locked out and removed by Division 26 demolition contractor.

F. Existing Conditions: For renovation of existing facilities which are occupied:
a. Do not interrupt the utilities serving existing facilities while occupied or partially occupied without coordinated arrangement for temporary utilities according to the requirements listed and written approval from the Owner.
i. Do not proceed with proposed utility interruptions without permission from the Owner.
ii. Submit a utility outage plan for approval by the Owner no less than seven (7) days prior to include, at minimum:
1. Utilities to be disrupted.
2. Length of disruption.
3. Plan for Fire Watch

b. Coordinate installation of new products and systems with all existing installations which are existing to remain in the project area, including but not limited to:
i. Plumbing, including domestic water, sanitary waste and vent piping and storm drain piping.
ii. Fire protection and suppression piping.
iii. HVAC Service Piping, including heating, cooling, condenser, steam, condensate, compressed air, and refrigerant piping.
iv. Piping Expansion Fittings
v. Ductwork
vi. Electrical Conduit, Cable Tray, Raceway
vii. Lighting Fixtures and Luminaires
viii. Existing IT Infrastructure, including wireless routers, cabling, and wire trays.

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ix. Existing Security Infrastructure, including cameras, and door contactors and operators
x. Existing Fire Alarm and Life Safety Infrastructure, including smoke and fire detectors, annunciators, strobe lights, exit signs, and extinguishers.

c. Provide Shop Drawings for all connections to existing systems including transitions in ductwork and pipe fittings.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance requirements, provide a product from one of the listed manufacturers. Any manufacturer specifically mentioned on the drawing shall be considered Basis – of – Design.

B. Available or Acceptable Manufacturers: Manufacturers of known equivalence. When listed, provide a product by one of the manufacturers listed or submit a non-listed manufacturer's product for review. Contractor is responsible for all cost deviations arising from use of a non-listed manufacturer.

2.1 ELECTRICAL REQUIREMENTS

A. Electrical Characteristics for HVAC Equipment: Unless otherwise approved, supply equipment with the electrical characteristics as indicated in the contract documents.

B. Equipment with electrical characteristics different from those indicated in the contract documents shall only be supplied if the following is approved in writing:
   a. The electrical supply wiring and conduit size is properly coordinated and modified.
   b. The electrical over-current protection device is properly coordinated and modified.
   c. The changes associated with panelboards, local transformers, and disconnects are properly coordinated and modified.
   d. Any additional costs of other contractors associated with the change in electrical characteristics are the responsibility of the Mechanical Contractor

2.2 PIPE, TUBE, AND FITTINGS

A. See Section 231113 Hydronic Piping and 231116 Hydronic Piping Specialties
B. See Section 232300 Refrigerant Piping

2.3 DUCTWORK

A. See Section 233100 HVAC Ducts and Casings and 233300 Duct Accessories

2.4 GROUT

A. Description: ASTM C 1007B, nonshrink and nonmetallic, dry hydraulic-cement grout
   a. Post Hardening, volume adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications
   b. 5000-PSI, 28-day compressive strength
   c. Premixed or packaged

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2.5 JOINING MATERIALS

A. Refer to Division 23 Piping Sections for special joining materials not listed below. When joining materials are in conflict, utilize the joining materials specified in the piping specific application specification.

B. Pipe-Flange Gasket Materials: Suitable chemical and thermal conditions for the specific use of the piping as specified in other Division Piping Sections

   a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless otherwise indicated
      i. Full-Face: Flat-Face, Class 125, cast-iron and cast-bronze flanges
      ii. Narrow-Face: Raised-Face, Class 250, cast-iron and steel flanges
   b. AWWA C110, rubber, flat face, 1/8-inch-thick, full face or ring type, unless otherwise indicated

C. Flange Bolts and Nuts: ASME B182.1, Carbon Steel, unless otherwise indicated

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material as recommended by piping system manufacturer for intended service, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys with ASTM B 813 water flushable flux. Melting point suitable for service.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorous alloys for general-duty brazing, unless otherwise indicated.

   a. Refrigerant Piping Brazing Filler Metals: AWS A5.8, Bagl, Silver alloy, unless otherwise specified by the manufacturer's written installation instructions.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for the wall thickness and chemical composition of the steel pipe being welded.

H. Solvent Cements for Plastic Pipe

   a. PVC Piping:
      i. Solvent Cement: ASTM 2564
      ii. Primer: ASTM F 6565
   b. CPVC Piping:
      i. Solvent Cement: ASTM 493

PART 3 - EXECUTION

3.1 PRE-WORK INSPECTION

A. Examine the work area before beginning installation. Ensure
   a. Conditions are safe and satisfactory for working.
   b. Rough-In work is installed properly.
   c. All coordination activities are successfully completed.
   d. The area is free of conflicts to proper installation.

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B. Do not proceed with work if conditions are unsatisfactory.

3.2 PLANNING

A. Plan work beforehand.

B. Communicate work plan to other contractors performing work in the area

C. Coordinate all work as listed in the Coordination Section of this specification.

3.3 HVAC DEMOLITION

A. Refer to general demolition specifications in division 02.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components as indicated.

a. To Be Removed: Uninstall and remove from site, including all insulation, pipe or ductwork, hangers and supports, specialties, and appurtenances as indicated. Cap at limits of demolition with same or compatible material if portion of service is existing to remain.
b. To Be Abandoned in Place: Disconnect from main service, drain, clean, and cap with same or compatible material.
c. Existing to Remain: Do not remove. Contractor is responsible for maintaining in a serviceable condition during work.

C. Contractor shall be responsible for replacing and repairing items that are existing to remain yet damaged by the contractor during work.

3.4 INSTALLATION

A. Install mechanical items in accordance with the contract documents and manufacturer's published installation instructions.

3.5 CONCRETE BASES

A. Anchor equipment to concrete base according to equipment manufacturer's published installation instructions and in accordance with seismic requirements, if present.

B. Construct concrete bases of dimensions indicated, but not less than 6 inches larger than supported unit in all directions.

C. Install dowel rods 18 inches on center to connect concrete base to concrete floor.

D. Install epoxy-coated anchor bolts for supported equipment that extends through the concrete base and anchor to structural floor.

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E. Place and secure anchorage devices using supported equipment manufacturer's published documentation, including setting drawings, diagrams, templates, instructions furnished with equipment to be supported.

F. Use 3000 PSI 28-day compressive strength concrete and reinforcements as specified in Division 03.

G. Ensure anchor bolts have proper exposed elevation to properly secure equipment to base.

3.6 GROUTING

A. Mix and install grout for HVAC equipment base bearing surface, pump, and other equipment base plates, and anchors.

B. Clean all surfaces to be grouted prior to installing grout.

C. Provide forms as needed to properly install grout.

D. Place grout, completely filling bases and forms.

E. Avoid entrapment of air within the grout during installation.

F. Place grout on concrete bases and provide smooth and level bearing surfaces for equipment to be supported

G. Place grout around anchors.

H. Cure placed grout.

3.7 METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 for structural steel requirements.

B. Metal Channel ("strut") products in accordance with the Metal Framing Manufacturer's Association standards may be used for metal framings, supports, and anchorages.

C. Cut, fit, and place miscellaneous metal supports accurately in locations as needed, with proper alignment and elevation required to support and anchor HVAC materials and equipment as intended in the contract documents.

D. Field Welding shall comply with AWS D1.1

3.8 WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages as needed to support and anchor HVAC equipment and materials.

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B. Select fasteners that will not penetrate wood members through a finished or exposed side. Tighten connections between members. Do not install fasteners resulting in split or weakened wood members.

C. Attach to substrates as required to support the sum of the dead load and applied working load of supported equipment.

3.9 EQUIPMENT INSTALLATION – COMMON REQUIREMENTS

A. Contractor shall confirm proper fit of equipment.

B. Install equipment level and plumb.

C. To the extent possible, install equipment and products perpendicular and parallel to exterior walls unless otherwise indicated.

D. Install equipment perpendicular and parallel to other building systems and components unless otherwise indicated.

E. Install all HVAC products and equipment:

a. To maximize headroom if specific mounting height is not specified.
b. To facilitate maintenance and service.
c. To maintain manufacturer's recommended minimum clearances.
d. To meet NFPA 70 required clearances to electrical components.
e. To allow space for installation of necessarily sloped items at intended slope.

F. Connect equipment for ease of disconnecting and removing, with minimum interference to other installations

G. Extend grease fittings to accessible locations outside of motor compartments and equipment casings.

3.10 CLEANING AND RESTORATION

A. Contractor shall repair damage resulting from the contractor's work.

B. Leave the work area broom clean at the end of each work shift.

C. Thoroughly clean the work area at the completion of construction. At a minimum, Contractor shall:

a. Remove all excess grout, paint, plaster, caulk, firestopping, or other products used during installation of HVAC systems from finished surfaces.
b. Clean duct systems clear of construction debris and dust.
c. Clean the blowers, fan housings, discharge plenums, scrolls, blades, vanes, shafts, baffles, dampers, and drive assemblies of all air handling units and fans free of construction debris and dust.

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d. Clean all coils dust free and render Coil Visibly Clean and within 10% of design coil pressure drop.
e. Clean all drain pains free of debris and dust.
f. Clean all dust from diffusers, registers, and grilles.
g. Clean, empty, and replace all strainer baskets.
h. Clean debris from all insect and bird screens.
i. Install new, clean air filters.
j. Remove all trash from mechanical equipment rooms.
k. Sweep clean all mechanical rooms.
l. Remove dust from exposed equipment casings.
m. Ensure all equipment tags and labels are clean and legible.

3.11 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to start up, test, and inspect mechanical equipment components, assemblies, connections, and installations as indicated.

B. Non-Conforming Work: Items shall be deemed defective if they do not pass tests and inspections, including commissioning functional testing.

3.12 FIELD PAINTING

A. When field applied coatings are specified, painting of HVAC Systems, equipment, and components is specified in Division 09.

B. Damage and Touchup: Marred, scratched, dinged, or otherwise damaged factory finishes shall be repaired with materials to match original factory finish using the manufacturer's approved methods.

3.13 OWNER TRAINING

A. Contractor shall provide training to the Owner's maintenance personnel on the systems and equipment installed. Training shall include, at a minimum:
   a. Means of turning equipment on and off safely.
   b. Review of Equipment Sequences and Operation.
   c. Review of Equipment Capacities and Capabilities.
   d. Means of making minor adjustments to setpoints.
   e. Review of Building Automation Systems.
   f. Basic Maintenance requirements.
      i. Filter Change Parameters and procedures.
      ii. Fan Belt Change Procedures.
      iii. Bearing Grease extension locations.
      iv. Greasing Intervals.
      v. Strainer cleaning procedures and intervals.
      vi. Turnover of Substantial Completion Hard Copy.

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END OF SECTION 230000

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SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes single- and three-phase motors for application on equipment provided under other sections and for motors furnished loose to Project.

B. Related Sections:

1. Section 260526 - Grounding and Bonding for Electrical Systems.
2. Section 260553 - Identification for Electrical Systems.

1.2 REFERENCES

A. American Bearing Manufacturers Association:

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.

C. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

A. Section 013300 - Submittal Procedures: Submittal procedures.

B. Action Submittals:
1. Product Data:
   a. Submit catalog data for each motor furnished loose. Indicate nameplate data, standard compliance, electrical ratings and characteristics, and physical dimensions, weights, mechanical performance data, maintenance procedures and intervals, and support points.
   b. Submit data for each motor furnished as a package with the package submittal. Indicate nameplate and performance data, standard compliance, electrical ratings and characteristics and maintenance procedures and intervals.

2. Test Reports: Indicate procedures and results for specified factory and field testing and inspection.

C. Information Submittals:

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1. Motor Manufacturer's published Operation and Maintenance Data, to be included in close out submittals.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

B. Testing Agency: Company specializing in testing products specified in this section with minimum three <3> years' documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Section 016000 - Product Requirements: Product storage and handling requirements.

B. Lift only with lugs provided. Handle carefully to avoid damage to components, enclosure, and finish.

C. Protect products from weather and moisture by covering with plastic or canvas and by maintaining heating within enclosure.

D. For extended outdoor storage, remove motors from equipment and store separately.

1.6 COORDINATION

A. Coordinate all features of motors, installed units, and accessory devices to be compatible with:

1. Means of Motor Starting.
2. Torque, speed, and mechanical power requirements of the application.
3. Ratings and characteristics of the electrical supply circuit.
4. Means of speed control.
5. Ambient and environmental conditions, both during storage and in the final installed location.

B. Coordinate all motor installation requirements with Division 26 contractor.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS FOR MOTORS FURNISHED WITH EQUIPMENT

A. Motors 1/2 hp and Larger: Three-phase motor as specified below.

B. Motors Smaller Than 1/2 hp: Single-phase motor may be supplied as specified below, except motors less than 250 watts or 1/4 hp may be equipment manufacturer's standard.

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C. Three-Phase Motors: NEMA MG 1, Design B, premium-efficient squirrel-cage induction motor, with windings to accomplish starting methods and number of speeds as indicated on Drawings.

1. Voltage: As indicated on Drawings
2. Service Factor: 1.15
3. Enclosure: Meet conditions of installation unless specific enclosure is indicated on Drawings.
4. Design for continuous operation in 40 degrees C environment, with temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
5. Design Code: Design B
6. Insulation System: NEMA Class F.
7. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
8. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.
9. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
10. Sound Power Levels: Conform to NEMA MG 1.

D. Single Phase Motors:

1. Permanent split-capacitor type where available, otherwise use split-phase start/capacitor run or capacitor start/capacitor run motor.
2. Voltage: as indicated on the drawings, single phase, 60 Hz.

E. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

2.2 THREE-PHASE MOTORS FURNISHED LOOSE

A. Acceptable Manufacturers: Acceptable Manufacturer’s are listed below. Other manufacturers of equivalent products may be submitted for review.

1. General Electric
2. Siemens
3. Baldor
4. Marathon Electric Company

B. Product Description: NEMA MG 1, Design B, premium-efficient squirrel-cage induction motor, with windings to accomplish starting methods and number of speeds indicated.

C. Voltage: as indicated on the drawings, three phase, 60 Hz.

D. Service Factor: 1.15

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E. Enclosure: Meet conditions of installation unless specific enclosure is specified or indicated.

F. Design for continuous operation in 40 degrees C environment, with temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

G. Insulation System: NEMA Class F.

H. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

I. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.

J. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

K. Sound Power Levels: Conform to NEMA MG 1.

L. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

2.3 SOURCE QUALITY CONTROL

A. Test motors in accordance with NEMA MG 1, including winding resistance, no-load speed and current, locked rotor current, insulation high-potential test, and mechanical alignment tests.

PART 3 - EXECUTION

3.1 EXISTING WORK

A. Disconnect and remove abandoned motors

B. Maintain access to existing motors and other installations remaining active and requiring access. Modify installation or provide access panel.

C. Clean and repair existing motors to remain or are to be reinstalled.

3.2 INSTALLATION

A. Install securely on firm foundation. Mount ball bearing motors in accordance with motor manufacturer's requirements.

B. Install engraved plastic nameplates in accordance with Section 260553 for all motors.

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C. Electrical Installer shall provide and install all necessary materials and labor to ground and bond motors in accordance with Section 260526.

3.3 FIELD QUALITY CONTROL

A. Perform inspections listed in NETA ATS, Section 7.15 for Rotating Machinery.

B. Perform Insulation Resistance Testing on all motor installations for the nominal voltage rating of the equipment. Motors that do not meet the minimum insulation resistance value tabulated in ANSI/NETA ATS-2009, summarized below, shall be reworked or replaced until the motor passes testing.

Nominal Rating of Equipment (volts)	Minimum Test Voltage, DC	Minimum Insulation Resistance in Megohms
<250	500	25
250 < Rated Volts < 600	1,000	100

END OF SECTION 230513

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SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Expansion joints.
2. Alignment guides and anchors.
3. Pipe loops and swing connections.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.

2. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

    a. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
    b. Alignment Guide Details: Detail field assembly and attachment to building structure.
    c. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

B. Closeout Submittals:

1. Maintenance Data: For expansion joints to include in maintenance manuals.

1.3 QUALITY ASSURANCE

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

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKED EXPANSION JOINTS

A. Flexible, Ball-Joint Packed Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Hyspan Precision Products, Inc.; Barco.
    b. Advanced Thermal Systems, Inc.

2. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
3. Material: Carbon-steel assembly with asbestos-free composition packing.
4. Design: Provide 360-degree rotation and angular deflection.
5. Minimum Pressure Rating: 150 psig at 600 deg F.
6. Angular Deflection: 15 degrees minimum.
7. Seal Type: Two carbon steel and graphite seals suitable for continuous operation at temperature up to 650 deg F.
8. Internal Ball: Plated with minimum 1-mil chrome cover.
9. Ball Socket: One- or two-piece design with integral socket/retainer.

    a. Stuffing Box: Incorporates containment seals and compression seals for containment of injectable packing.
    b. Packing Cylinders: Provides packing under full line pressure with check valves to prevent blowback.

10. End Connections: Threaded, flanged, or welded as indicated.

B. Slip-Joint Packed Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Adsco Manufacturing LLC; model RBJ.

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b. Advanced Thermal Systems, Inc.
c. Hyspan Precision Products, Inc.

2. Standard: ASTM F 1007.
3. Material: Carbon steel with asbestos-free PTFE packing.
4. Design: With internal guide and injection ports for repacking under full system pressure. Housing shall be furnished with drain ports and lifting ring. Include drip connection if used for steam piping.
5. Configuration: Single joint, single joint with base, or double joint with base as indicated.
6. Slip Tube for sizes NPS 1-1/2 through NPS 16: Schedule 80.
7. Sliding Surface: 2-mil thick chrome finish.
8. End Connections: Flanged or welded ends to match piping system.
9. Packing: Carbon fiber impregnated braided rope with graphite or PTFE injectable sealant.

2.3 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Metraflex Company; model Metraloop.
b. Flexicraft Industries.
c. General Rubber Corporation.
d. Mason Industries, Inc.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 4 and Smaller: Copper-alloy fittings with solder-joint end connections. Bronze or stainless steel corrugated hoses and double-braid bronze or stainless-steel sheaths with minimum 225 psig at 70 deg F rating.
5. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections. Stainless-steel hoses and double-braid, stainless-steel sheaths with minimum 500 psig at 70 deg F rating.
6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 12: Carbon-steel fittings with flanged end connections. Stainless-steel hoses and double-braid, stainless-steel sheaths with minimum 160 psig at 70 deg F rating.

B. Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

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a. Flexicraft Industries; model N.
b. Hyspan Precision Products, Inc.
c. Metraflex Company.

2. Standards: ASTM F 1120 and EJMA "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Type: Circular, corrugated bellows.
4. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
5. Configuration: Single joint, unless otherwise indicated.
6. Expansion Joints for Steel Piping: Multi-ply stainless-steel bellows, flanged steel pipe ends, and carbon-steel shroud.

C. Externally Pressurized Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Hyspan Precision Products, Inc.; series 3500.
b. Flexicraft Industries.
c. Mason Industries, Inc.
d. Metraflex Company.

2. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
3. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by internal pipe sleeve.
4. Carbon-steel housing.
5. Drain plugs and lifting lug for NPS 3 and larger.
6. Operating clearance for bellows between internal pipe sleeve and external shroud.
7. Scale to confirm the starting position and operating movement.
8. Joint Axial Movement: 4, 6, or 8 inches of compression and 1or 2 inches of extension as indicated.
9. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
10. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

D. Rubber Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Metraflex Company; model Double Cablesphere.
b. Flexicraft Industries.
c. General Rubber Corporation.

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d. Mason Industries, Inc.

2. Standards: ASTM F 1123 and FSA "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
4. Spherical Type: Two spheres with external control cables or rods.
5. Minimum Pressure Rating: 150 psig at 200 deg F.
6. Sphere Material: EPDM, butyl rubber, neoprene, or nitrile rubber to suit fluid chemical composition.
7. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.4 GROOVED-JOINT EXPANSION JOINTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Victaulic Company; style 155.
2. Approved equal.

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: Seven, unless indicated otherwise, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N or EPDM gaskets suitable for chemical composition, and bolts and nuts.

2.5 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Metraflex Company; style IV or PG.
b. Flexicraft Industries.
c. Hyspan Precision Products, Inc.
d. Mason Industries, Inc.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

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B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, stainless or zinc-coated carbon steel.
    b. Expansion Plug: Stainless or zinc-coated steel.
    c. Washer and Nut: Stainless or zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: ASTM A 307, stainless or zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
    c. Washer and Nut: Stainless or zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing types and materials suitable for fluid service.

C. Install metal-bellows expansion joints according to "Standards of the Expansion Joint Manufacturers Association, Inc."

D. Install rubber packless expansion joints according to FSA-PSJ-703.

E. Install grooved-joint expansion joints only in grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect branch lines with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

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B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 23 05 16

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SECTION 230517 – SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-Seal Systems.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data for each type of product to be installed.

B. Information Submittals:

1. Maintenance Data: For each type of product to be installed.

PART 2 – PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to the ductile iron pressure pipe, with plan ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/53M Schedule 40, with plan ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/53M, Type E, Grade B, Schedule 40, zinc coated with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness with round tube, closed with a longitudinal joint.

E. PVC-Pipe Sleeves: STM D 1785 Schedule 40.

F. Molded-Polyethylene or Polypropylene Sleeves: Removable, tapered cup shaped, smooth outer surface with nailing flange to attach to framing member.

G. Molded PVC Sleeves: With nailing flange to attach to framing member.

2.2 SLEEVE SEAL SYSTEMS

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A. Acceptable Manufacturers: Acceptable Manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Metraflex
2. Advance Products & Systems
3. GPT
4. Pipeline Seal and Insulator

B. Description: Modular sealing-element unit, designed for assembly in the field, intended to fill annular space between piping and pipe sleeve.

1. Basis of Design Product: Metraflex MS series
2. Sealing Pressure: 20 PSIG air and / or 40 ft Head water.
3. Sealing Elements: EPDM-Rubber interlocking links shaped to fit pipe surface snug. Include type and number required for pipe size and material.
4. Pressure Plates:
   a. Glass reinforced plastic, under maximum media temperature of 250 degrees F.
   b. Steel, Zinc Dichromate over maximum media temperature of 250 degrees F or when exposed to weather.
5. Connecting Bolts and Nuts:
   a. Carbon Steel for interior installations.
   b. Stainless Steel or Steel, Zinc Dichromate, or equivalent corrosion-resistant hardware for underground or exterior wall penetrations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install sleeves for piping penetrations through all floors, walls, partitions, and roofs.

1. Install sleeves in concrete floors, roof slabs, and walls as new floor, slab, or wall is constructed.
2. Select sleeves to receive sleeve seal systems to have a nominal 1-inch annular space between piping and concrete, excluding insulation.
3. Select sleeves not receiving sleeve seal systems to have 1/4 - inch clear annular space between sleeve and insulation of piping system.
4. Cut sleeves to length such that sleeve is flush with both finished surfaces.

   a. All sleeves in through floors in mechanical rooms shall extend 2” above finished floor surface.

5. Install piping through center of sleeve. Align centerlines of sleeve and pipe.
6. Fill the area outside of sleeves with grout.
7. Fill the annular area inside of sleeves without sleeve seal systems with caulk. Piping insulation of the pipe penetrating shall have an insulation jacket compatible with the caulk. Refer to section 079200 for “Joint Sealants” for non-fire rated walls.
8. For all penetrations through Fire-Barriers, maintain the indicated rating of the barrier. Seal pipe penetration with firestop materials. Comply with firestopping requirements as specified in section 078413 “Penetration Firestopping”

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B. Install sleeve-seal-systems in exterior walls, and piping service installations through slabs-on-grade.

1. Select type, size, and number of sealing elements required for penetrating pipe characteristics per manufacturer's written instructions.
2. Align the centerline of installed piping with the centerline of pipe sleeve.
3. Install sleeve-seal-system links in annular space per manufacturer's published instructions.

C. Install weatherproof wall box penetrations per manufacturer's written instructions.

END OF SECTION 230517

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SECTION 23 05 18 – ESCUTCHEONS FOR HVAC PIPING

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes:
   a. Escutcheons.
   b. Floor plates.

1.2 SUBMITTALS

A. Action Submittals:
   a. Product Data for each type of product indicated.

PART 2 – PRODUCTS

2.1 ESCUTCHEONS

A. One-piece, steel type: With polished, chrome-plated finish and set screw fastener.

B. One-piece, stainless steel type: With polished, stainless steel finish.

C. One-piece, stamped steel type: with polished, chrome-plated finish and spring-clip fastener.

D. One-piece, deep-pattern type: Deep-draw, box-shaped steel with polished, chrome-plated finish and spring clip fastener.

E. Split-plate, stamped steel type: with polished, chrome-plated finish; concealed or exposed rivet hinge and spring clip fastener.

2.2 FLOOR PLATES

A. Split floor plates: Steel with concealed hinge.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install escutcheons for all interior exposed piping penetrations through floors, walls, and ceilings.

B. Install escutcheons with inside diameter closely fitting around outside diameter of piping and piping insulation and outside insulation completely covering opening and pipe sleeve.

C. Install escutcheons fitting to the piping type:

   a. Pipe Sleeve through wall: one-piece deep pattern.

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b. Uninsulated piping: Split Plate Steel.
c. Insulated Piping: Split Plate Steel.

D. Install floor plates for piping penetrations through mechanical room floors that do not have extended pipe sleeves.

E. Install floor plates with the inside diameter loosely fitting around piping and pipe insulation and the outside diameter covering the pipe sleeve and opening completely.

END OF SECTION 230518

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SECTION 230519 METERS AND GAUAGES OR HVAC

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes:

1. Bi-metallic-actuated thermometers.
2. Gas Actuated Thermometers.
3. Liquid-in-glass Thermometers.
4. Thermowells.
5. Pressure gauges.
    a. High Pressure gauges.
    b. Low Pressure gauges.
6. High Pressure gauge accessories.
7. Test plugs.
8. Test plug kits.

1.2 ACTION SUMBITTALS

A. Product Data: For each type of product indicated.

PART 2 – PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Acceptable manufacturers: Acceptable manufacturers are listed below. Other manufacturer's product may be submitted for review provided that product meets or exceeds the performance characteristics indicated.

1. Ashcroft Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

B. Basis of Design Products:

1. Ashcroft EI Series.

C. Physical Characteristics:

1. Compliant with ASME B40.200.
2. Nominal 3-inch diameter face.
3. Nonreflective face with markings in scales for degrees F and degrees C.
4. Accuracy of +/- 1.5% full span or better.
5. Connection – ½-inch NPT.

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6. Thermowell required.
7. Insertion length as needed to penetrate 1/3rd of pipe or duct diameter but no greater than 8" into duct, or 1/3rd of door width when installed in an equipment door.
8. Field adjustable.
9. Safety Glass Face.
10. Range per application
    a. Water: 0- 250 degrees F.
    b. Steam: 50-550 degrees F.
    c. HVAC Supply and Return Air: 0 – 200 degrees F.

2.2 GAS ACTUATED THERMOMETERS

A. Acceptable manufacturers: Acceptable manufacturers are listed below. Other manufacturer's product may be submitted for review provided that product meets or exceeds the performance characteristics indicated.

1. Ashcroft Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

B. Direct mounted, metal case, vapor actuated thermometer:

1. Basis of Design: Ashcroft 600 series.
2. Compliant with ASME B40.200.
3. Minimum Nominal 3-inch diameter face.
4. Nonreflective face with markings in scales for degrees F and degrees C.
5. Accuracy of +/- 1.0% full span or better.
6. Connection – ½-inch NPT.
7. Thermowell required.
8. Insertion length as needed to penetrate 1/3rd of pipe or duct diameter but no greater than 8" into duct, or 1/3rd of door width when installed in an openable equipment door.
9. Field adjustable.
10. Safety Glass Face.
11. Range per application
    a. Water: 0- 250 degrees F.
    b. Steam: 50-550 degrees F.
    c. HVAC Supply and Return Air: 0 – 200 degrees F.
    d. Boiler Exhaust: 50 to 550 degrees F.

C. Remote mounted, metal case, vapor actuated thermometer:

1. Basis of Design: Ashcroft 600A series.
2. Compliant with ASME B40.200.
3. Minimum Nominal 4-1/2-inch diameter face.
4. Nonreflective face with markings in scales for degrees F and degrees C.
5. Accuracy of +/- 1.0% full span or better.
6. Connection – ½-inch NPT.

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7. Thermowell required for piping applications.
8. Insertion length as needed to penetrate 1/3rd of pipe or duct diameter but no greater than 8" into duct, or 1/3rd of door width when installed in an openable equipment door.
9. Field adjustable.
10. Safety Glass Face.
11. Include ventilated shrouds in duct applications.
12. Range per application
    a. Water: 0- 250 degrees F.
    b. Steam: 50-550 degrees F.
    c. HVAC Supply and Return Air: 0 – 200 degrees F.
    d. Boiler Exhaust: 50 to 550 degrees F.

2.4 LIQUID IN GLASS THERMOMETERS

A. Acceptable manufacturers: Acceptable manufacturers are listed below. Other manufacturer's product may be submitted for review provided that product meets or exceeds the performance characteristics indicated.

1. Trerice, H. O. Co.
2. Miljoco
3. S.H.M.
4. Winters Instruments – U.S.
5. Weiss Instruments, Inc.

B. Direct mounted, metal case, liquid in glass thermometer:

1. Basis of Design: H.O. Trerice Adjustable Angle
2. Compliant with ASME B40.200.
3. Fill type: Spirt
4. Fill Color: Blue, organic
5. Case: Cast Aluminum, Epoxy Finish or equivalent
6. Stem: Aluminum or brass.
7. Window: Acrylic or Safety Glass
8. Tube: Lens front. Magnifying type optional.
9. Scale: Aluminum, white background with black graduations and markings.
10. Accuracy +/- 1 scale division.
11. Scale Height: 9-inch.
12. Minimum duct insertion length: 12-inch.
13. Utilize manufacturer duct mounting accessories.
14. Range per application:
    a. Chilled water: -40 to 110 degrees F.
    b. Condenser, Cooling Tower, or Tempered Water: 30 to 130 degrees F.
    c. Heating Hot Water or Steam Condensate: 30 to 240 degrees F.
    d. Steam: 50 to 400 degrees F.
    e. Boiler Exhaust: 50 to 500 degrees F.
    f. HVAC Supply, Return Air Duct: 30 to 130 degrees F.
    g. HVAC Outdoor Air Intake: 0 to 100 degrees F.

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15. Coordinate scale to element angle to allow for visibility and ease of reading while standing on the ground.

2.4 THERMOWELLS

A. Acceptable manufacturers: Acceptable manufacturers are listed below. Other manufacturer's product may be submitted for review provided that product meets or exceeds the performance characteristics indicated.

1. Same Manufacturer as Instrument as able.

B. Characteristics:

1. Comply with ASME B40.200
2. Pressure-tight, socket-type fitting made for insertion in pipe tee or weld-o-let fitting.
3. Copper Tubing main shall utilize CNR or CUNI thermowells.
4. Steel Piping Main shall use CRES or CSA thermowells.
5. Coordinate threaded connections with piping installation.
6. Coordinate well depth with instrument length to meet minimum insertion requirements.
7. Utilize a heat transfer paste rated for the application temperature ranges.

2.6 PRESSURE GAUGES

A. Acceptable manufacturers: Acceptable manufacturers are listed below. Other manufacturer's product may be submitted for review provided that product meets or exceeds the performance characteristics indicated.

1. Ashcroft
2. Dwyer Instruments
3. Trerice, H. O. Co.
4. Miljoco
5. Palmer Wahl Instrumentation Group
6. Winters Instruments – U.S.
7. Weiss Instruments, Inc.

B. Common Requirements for Water and High-Pressure Air Service Pressure Gauges.

1. Compliant with ASME B40.100.
2. Grade 1A +/- 1.5 percent of span.
3. Case: Sealed, Open front, pressure relief type, Cast Aluminum or Stainless Steel.
4. Safety Glass face.
5. Bourdon tube assembly, unless otherwise noted.
6. Minimum 2-1/2" diameter.
7. Non-reflective dial with permanently etched scale markings graduated in PSI.
8. Instrument connection 1/4-inch NPT.

C. Basis of Design Products:

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1. Water less than 150 degrees F: Palmer 45SB
2. Water greater than 150 degrees F: Palmer 60SS

D. Low Pressure Differential Air Pressure Gauges.

1. Basis of Design Product: Dwyer Magnehelic Series 2000
2. Accuracy +/- 2 percent of span
3. Housing: Cast Aluminum
4. Plastic or Safety Glass face.
5. Non-reflective dial with permanently etched scale markings graduated in fractions of an inch of water column.
6. Instrument connection two by 1/8-inch NPT.
7. Suitable for use in 20 to 120 degrees F.
8. Install diaphragm in vertical position.
9. Install surface mounted on duct or equipment casing or within enclosure.

E. Low Static Pressure Gauges

1. Basis of Design Product: Dwyer Series Mark II
2. Accuracy +/- 3 percent of span
3. Housing: Molded Plastic
4. Maximum working Pressure – 15 PSI
5. Plastic or Safety Glass face.
6. Non-reflective dial with permanently etched scale markings graduated in fractions of an inch of water column.
7. Instrument connection two by 1/8-inch NPT.
8. Suitable for use in 20 to 120 degrees F.
9. Install surface mounted on duct or equipment casing.
10. Coordinate range with application, with maximum reading either 3 or 7 inches of water.

2.6 HIGH PRESSURE GAUGE ACCESSORIES

A. Valves: Brass Ball, NPS 1/4-inch ASME B1.20.1 pipe threads.

B. Siphons: Loop-shaped section of pipe with NPS 1/4-inch threads.

C. Snubbers: ASME B40.100, brass, with NPS 1/4-inch ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include insulation extensions.

2.7 TEST PLUGS AND KIT

A. Acceptable Manufacturer's: Acceptable manufacturers are listed below. Other manufacturer's product may be submitted for review provided that product meets or exceeds the performance characteristics indicated.

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1. Flow Design, Inc.
2. Mijoco Corporation
3. Weiss Instruments, Inc.
4. Peterson Equipment Company, Inc.

B. Test Plugs

1. TEE Insertion Type.
2. Brass or stainless steel body with EPDM self-sealing core inserts and gasketed threaded cap.
3. Include extend stem for insulated piping.
4. Minimum Pressure and Temperature Rating: 500 PSIG at 200 degrees F.
5. Utilize a single test plug manufacturer in all work of a single discipline.

E. Test Kit

1. Provide test kit from the same manufacturer as test plugs.
2. Furnish the following with the test kit:

    a. One High Range thermometer: Small bi-metallic insertion type with 1 to 2-inch diameter dial and tapered-end sensing element ranged for 0 to 220 degrees F.
    b. One Low Range Thermometer: Small bi-metallic insertion type with 1 to 2- inch diameter dial and tapered-end sensing element ranged for 25 to 125 degrees F.
    c. One pressure gauge: 2-1/2-inch dial, bourdon tube-type with insertion needle ranged from 0 to 200 PSIG.
    d. One Carrying case: Metal or plastic, with formed instrument padding, of sufficient size to store entire kit.
    e. Six Adapter probes of sufficient size to attach to all test plugs provided.

PART 3 – EXECUTION

A. Install thermowells in the vertical position with socket extending no less than one-third but no more than one-half into the pipe. Tilt as required to allow reading of thermometer from a normal standing position.

B. Coordinate all thermowell installations to match thermometer connectors. Include bushings as required to match sizes. Extend thermowells above insulation.

C. Fill thermowells with heat transfer paste prior to inserting thermometer probe.

D. Install duct mounted thermometers utilizing manufacturer's bracket or flange fitting. When probes are installed on an openable equipment door, coordinate installation to prevent damage of probe when door is opened or closed without removing probe.

E. Install an isolation valve and snubber inline with each pressure gauge pipe connection to facilitate removal and cleaning of gauge without draining system.

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F. Install direct mounted pressure gauges in piping tees and locate gauge such that it is readable from a normal standing position on the ground.

G. Install remote mounted pressure gauges in panels unless otherwise indicated in installation detail drawings.

H. Consult all piping installation details for indicated thermometer locations. At minimum, thermometers shall be installed in the locations below:

1. Entering and leaving chiller barrels.
2. Entering and leaving boilers.
3. Entering and leaving Air Handler Coils.
4. Entering and leaving all sides of Heat Exchangers.
5. Entering and leaving storage tanks.
6. Air handler compartments associated with:
   a. Return Air
   b. Outside Air
   c. Preheat coil leaving Air
   d. Cooling coil leaving Air
   e. Supply Duct Entering Air

I. Install water service pressure gauges as indicated in the installation details and piping schematics. At minimum, pressure gauges shall be installed in the locations listed below:

1. Pump Suction and Discharge (May be a shared gauge with valve manifold)
2. Entering and Leaving each boiler.
3. Entering and leaving each chiller barrel.
4. Entering each storage tank.
5. Entering and leaving all sides of a heat exchanger.

J. Install low pressure air service pressure gauges as indicated in the installation details and piping schematics. At minimum, pressure gauges shall be installed in the locations listed below:

1. Static Pressure Gauges:
   a. Discharge duct main.
   b. Return duct main.
   c. Exhaust duct main.
2. Differential Pressure Gauges
   a. Air Handler Supply Fans
   b. Air Handler Return Fans
   c. Energy Recovery Exhaust Fans
   d. Filter Sections

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END OF SECTION 230519

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SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ball valves.
2. Butterfly valves.
3. Check valves.
4. Combination balancing and shutoff valves.
5. Gate valves.
6. Globe valves.
7. Chainwheels.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NPS: Nominal Pipe Size

D. OS&Y: Outside screw and yoke.

E. SWP: Steam working pressure.

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of valve indicated, include: Body, seating and trim materials; valve design; pressure and temperature classifications; end connections, arrangements; dimensions and required clearances. Submit pressure drop curves for no-slam check valves. Include a list indicating valve type and its piping system application. Include rated capacities; shipping and operating weights and furnished specialties and accessories.

B. Closeout Submittals:

1. Valve chart indicating valve identification number, valve type, service, manufacturer and model number, and location of valve.
2. Operating and maintenance manuals.

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1.4 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
   1. Grooved end valves shall be of the same manufacturer as adjoining couplings.

B. ASME Compliance:

   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.
   4. ASME Boiler Code Specifications for Boiler Room valves.

C. ASTM Compliance:

   1. ASTM B62 for 125 psi and 150 psi saturated steam rated valve pressure containing parts.
   2. ASTM B61 for 200 psi and 300 psi valves with metallic seats.

D. Factory test all valve bodies, shells and seats per MSS requirements at a minimum.

E. Iron Body Valves

   1. Pressure-Containing Parts: ASTM A126, Grade B.
   2. Face-to-Face and End-to-End Dimensions: ANSI B16.10.
   3. Design, Workmanship, Materials, Testing: MSS SP-70, 71, 85.

F. Butterfly Valves

   1. Face-to-Face and End-to-End Dimensions: MSS SP-67.

G. Valve Stems: ASTM B371, Alloy C69400; ASTM B371, Alloy C65100H04 (rolled silicon brass); or other material equally resistant to dezincification.

H. Valve Bypass and Drain Connections: MSS SP-45.

I. Pressure casting shall be free of impregnating materials, no welding of iron allowed.

J. Manufacturer’s name or trademark and working pressure stamped or cast into body.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooved ends, and weld ends.
   3. Set gate and globe valves closed to prevent rattling.
   4. Set ball valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

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1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. HVAC Hydronic Systems (Ball, Butterfly, Check, and Globe Valves):

    a. Crane.
    b. DeZurik.
    c. Hammond.
    d. Milwaukee.
    e. Mueller.
    f. NIBCO.
    g. Victaulic.
    h. Tyco.
    i. Watts.

2. HVAC Hydronic Systems (Combination Balancing and Shutoff Valves):

    a. Armstrong.
    b. Bell & Gossett.
    c. Griswold.
    d. IMI Hydronic Engineering
    e. Taco.
    f. Victaulic.

3. Coil Piping Packages (Coil Hook Ups):

    a. Bell & Gossett.
    b. Griswold.
    c. IMI Hydronic Engineering.
    d. Victaulic.

2.2 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

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B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures. Valves shall be rated for pressures and temperatures no less than 20% over that of the piping system in which they are installed. Account for piping system pressure tests when selecting component ratings.

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller.
4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Threaded: With threads according to ASME B1.20.1.

G. Combination Balancing and Shutoff Valves:

1. Install where shown on Drawings. Valves shall be designed and used only for balancing, not shutoff.
2. Provide a means for connecting to a portable differential pressure meter for readout. A portable pressure gauge, hoses and flow curves shall be provided in a portable test kit.
3. On sizes 2-1/2” and larger, valve size, capacity and operating pressure must comply with ASME Boiler Pressure Vessel Code: Section IV.
4. Refer to manufacturer’s recommendations for upstream and downstream straight piping lengths.
5. Provide an additional “separate” shutoff valve upstream of combination valves for system/component shutoff.

H. Coil Piping Packages / Coil Hook Ups:

1. Contractor has the option to use factory assembled valve packages in lieu of individual valves and ports as shown on the Drawings at any terminal unit connections.
2. Shall only be provided on pipes 1-1/2” and smaller.
3. All components shall be rated for 250 psig working pressure and shall be globe-type or full-port (full-bore) design.
4. The order and arrangement of components shall be consistent with the Drawings.

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5. Each individual component shall meet the specification requirements for components of a field-assembled system.

I. Multi-Purpose (Three-Function Valve or Triple Duty Valve):

1. Can be used in lieu of Combination Balancing and Shutoff Valve and Check Valve at Pump Discharge.
2. Triple Duty Valve manufacturer must be the same as pump manufacturer or approved grooved valve manufacturer.
3. Horizontal or vertical installation is acceptable; valve may be field convertible for straight or angled position.
4. Valve shall be a ductile iron body, bronze seat disc, with a 302 stainless steel spring.
5. Valve stem shall be made of bronze or 416 stainless steel with seal packing replaceable under pressure.
6. Bronze fitted construction.
7. Valve shall have a memory indicator, pointer and scale.
8. Schrader valve or P/T port metering connections.
9. O-ring sealed valve body shall be EPDM.
10. Replaceable ‘soft seat’ shall be EPDM.
11. The valve, in the full-open position shall have no more than 1 psi pressure drop across the valve.
12. Valve shall be constructed with a minimum of 125# working pressure (maximum 250#).
13. Valve shall be available in threaded for 2” and smaller and flanged or grooved end connections in 2-1/2” and larger.
14. Provide a separate shutoff valve upstream of triple duty valves when triply duty valves are used.

2.3 BALL VALVES

A. Bronze Ball Valves:

1. Description:

a. Standard: MSS SP-110.
b. ANSI Class: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded or Soldered for copper piping.
g. Seats: Reinforced PTFE.
h. Stem: Stainless steel.
i. Ball: Chrome plate ball, vented.
j. Port: Full.
k. Operator: Hand Lever.

2.4 BUTTERFLY VALVES

A. Single-Flange, Butterfly Valves:

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1. Description:

    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 150 psig.
    c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    d. Body Material: ASTM A 126, cast iron.
    e. Seat: EPDM.
    f. Stem: One- or two-piece stainless steel.
    g. Disc: Aluminum bronze.
    h. Operator: 10 Position Hand Lever for less than 6", Gear Actuator for 6" and larger.
    i. Other: Valves and Seats shall be rated for 150 psi shutoff during dead-end service, without downstream piping or flange.

B. Grooved-End, Butterfly Valves (Cast Brass):

1. Description:

    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 300 psig.
    c. Body Material: Cast brass.
    d. Stem: Two-piece stainless steel.
        1) Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating.
    e. Disc: Aluminum-bronze.
    f. Seal: Pressure-responsive EPDM.
    g. Copper-tube dimensioned grooved ends.

C. Grooved-End, Butterfly Valves (Iron):

1. Description:

    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 300 psig (24" and smaller).
    c. Body Material: Coated, ductile iron.
    d. Stem: Two-piece stainless steel.
        1) Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating.
    e. Disc: Coated, ductile iron.
    f. Seal: EPDM.
        1) Pressure responsive in sizes 12" and smaller.

2.5 CHECK VALVES

A. Lift Check Valves:

1. Description:

    a. Standard: MSS SP-80, Type 1.

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b. ANSI Class: 125
c. CWP Rating: 200 psig.
d. Body Design: Vertical flow.
e. Body Material: ASTM B 61 or ASTM B 62, bronze.
f. Ends: Threaded or Soldered for copper piping.
g. Disc: Reinforced PTFE.
h. Cap: Threaded.

B. Globe Body Silent Check Valves:

1. Description:

a. ANSI Class: 125
b. Body Material: ASTM A 48, Class 35, cast iron.
c. Disc Material: Cast Iron with Bronze Face Rings
d. Ends: Flanged or Wafer.
e. Trim: Bronze.
f. Spring Material: Stainless Steel T304 (ASTM A 276).

C. Piston Type Check Valves:

1. Description:

a. ANSI Class: 300 or 600
b. Body Material: ASTM A 105, forged steel.
c. Ends: Flanged.
d. Disc Material: Stainless steel (Type 410).
e. Seat: Integral.
f. Bonnet: Bolted.

D. Bronze Swing Check Valves:

1. Description:

a. Standard: MSS SP-80, Type 3.
b. ANSI Class: 125
c. CWP Rating: 200 psig.
d. Body Design: Horizontal flow.
e. Body Material: ASTM B 62, bronze.
f. Ends: Threaded or Soldered for copper piping.
g. Disc: Reinforced PTFE.
h. Cap: Threaded.

E. Iron Swing Check Valves:

1. Description:

a. Standard: MSS SP-71, Type I.
b. ANSI Class: 125
c. CWP Rating: 200 psig.
d. Body Design: Clear or full waterway.

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e. Body Material: ASTM A 126, cast iron.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Cap: Bolted.

F. Cast Steel Swing Check Valves:

1. Description:

a. ANSI Class: 300
b. Body Material: ASTM A 216, cast steel.
c. Disc Material (2" to 4"): Steel (ASTM A 217, Gr. CA-15).
d. Disc Material (6" to 12"): Steel with Hard Faced (ASTM A 216, Gr. WCB).
e. Ends: Flanged.
f. Seat Ring Material: Stellite hard facing over plain carbon steel.
g. Bonnet: Bolted.

G. Grooved-End, Spring-Assisted Swing Check Valves

1. Description:

a. CWP Rating:
1) 12” and smaller: 300 psig.
2) 14” to 24”: 230 psig.
b. Body Material: ASTM A 536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring-operated, ductile iron or stainless steel.
e. Installation: Vertical or horizontal.

2.6 COMBINATION BALANCING AND SHUTOFF VALVES

A. Calibrated Ball Type or Venturi Combination Balancing and Shutoff Valves:

1. Description:

a. CWP Rating: 125 psig.
b. Body Material: Brass or Bronze (ASTM B 62)
c. Ends: Flanged, Threaded or Soldered for copper piping.
d. Seat Material: Double-seated Teflon.
e. Ball Material: Stainless Steel.
f. Stem Material: Brass/Bronze sealed with blow-out proof EPDM O-Ring.
g. Operator: Lever with memory stop.

B. Venturi Butterfly or Venturi Globe Type Combination Balancing and Shutoff Valves:

1. Description:

a. CWP Rating: 125 psig.
b. Body Material: Ductile Iron, Cast Iron or Steel.

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c. Disc Material: Bronze.
d. Ends: Flanged or Threaded.
e. Stem Material: Stainless Steel.
f. Operator: Lever with memory stop.

2.7 GATE VALVES

A. Bronze Gate Valves:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. ANSI Class: 150
c. CWP Rating: 300 psig.
d. Body Material: ASTM B 62, cast bronze.
e. Ends: Threaded.
f. Stem: Non-Rising.
g. Disc: Solid wedge; bronze.
h. Packing: Asbestos free.
i. Bonnet: Union
j. Operator: Hand Wheel-Malleable iron.

B. Iron Gate Valves:

1. Description:

a. Standard: MSS SP-70, Type I.
b. ANSI Class: 125
c. CWP Rating: 200 psig.
d. Body Material: ASTM A 126, cast iron.
e. Ends: Flanged.
f. Wedge and Seat Rings Material: Cast bronze.
g. Disc: Solid wedge-Cast iron.
h. Packing and Gasket: Asbestos free.
i. Bonnet: Bolted
j. Stem: O.S. & Y.
k. Operator: Hand Wheel-Cast iron.

C. Forged Carbon Steel Gate Valves:

1. Description:

a. ANSI Class: 300 or 600
b. Body Material: ASTM A 105, forged carbon steel.
c. Ends: Flanged or weld.
d. Seat Ring Material: Hard faced stainless steel (Type 410).
e. Disc: Solid wedge-Stainless steel (Type 410).
f. Bonnet: Bolted
g. Packing and Gasket: Asbestos free.
h. Stem: O.S. & Y.

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i. Operator: Hand Wheel-Malleable iron.

D. Cast Steel Gate Valves:

1. Description:

a. ANSI Class: 300
b. Body Material: ASTM A 216, cast steel.
c. Ends: Flanged.
d. Seat Ring Material: Stellite hard facing over plain carbon steel.
e. Disc: Stainless steel (ASTM A 217).
f. Bonnet: Bolted.
g. Stem: O.S. & Y.
h. Operator: Hand Wheel-Malleable iron.

2.8 GLOBE VALVES

A. Bronze Globe Valves:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. ANSI Class: 150
c. Body Material: ASTM B 62, bronze.
d. Ends: Threaded or Flanged.
e. Stem: Rising.
f. Disc: 420 Stainless Steel.
g. Seat Ring Material: 420 Stainless Steel.
h. Bonnet: Union.
i. Operator: Hand Wheel-Malleable iron.

B. Iron Globe Valves:

1. Description:

a. Standard: MSS SP-85, Type I.
b. ANSI Class: 125
c. Body Material: ASTM A 126, cast iron.
d. Disc Material: ASTM B 62; Bronze.
e. Seat Ring Material: ASTM B 62; Bronze.
f. Ends: Flanged.
g. Bonnet: Bolted.
h. Stem: O.S. & Y.
i. Operator: Hand Wheel-Cast or malleable iron.

C. Forged Steel Globe Valves:

1. Description:

a. ANSI Class: 300 or 600

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b. Body Material: ASTM A 105, forged steel.
c. Disc Material: Loose-Stainless Steel (Type 410).
d. Seat Material (Class 300): Integral Hard Faced.
e. Seat Material (Class 600): Renewable Stainless Steel (Type 410)
f. Ends: Flanged or Butt Weld.
g. Bonnet: Bolted.
h. Stem: O.S. & Y.
i. Operator: Hand Wheel-Malleable iron.

D. Cast Steel Globe Valves:

1. Description:

a. ANSI Class: 300
b. Body Material: ASTM A 216, cast steel.
c. Disc Material: Stainless steel.
d. Seat Ring Material: Stellite hard facing over plain carbon steel.
e. Ends: Flanged.
f. Bonnet: Bolted.
g. Stem: O.S. & Y.
h. Operator: Hand Wheel, Hand Lever or Gear Actuator for 6” and larger.

2.9 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball and butterfly valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

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E. Do not attempt to repair defective valves; replace with new valves.

F. Examine grooved ends for form and cleanliness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

3.2 VALVE INSTALLATION

A. Install valves at locations shown on the Drawings, per the Specifications and in accordance with manufacturer's written instructions.

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

C. Unions and flanges for servicing and disconnect are not required in installations using grooved mechanical joint couplings (the couplings shall serve as disconnect points if required).

D. Locate valves for easy access and provide separate support where necessary.

E. Install valves in horizontal piping with handwheel and stem at or above center of pipe.

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

G. Install chainwheels on operators for all valves located with the lowest portion of its handwheel or lever at 10' or more above finished floor. Extend chains to 5' above finished floor.

H. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Lift Check Valves: With stem upright and plumb.

I. Install Combination Balancing and Shutoff Valves at each branch connection to return main.

J. Install Start/Stop flow valve for isolation at each branch connection to supply main.

K. Install check valves at each pump discharge and elsewhere as required to control flow direction.

L. All check valves should be installed in a location that has smooth and laminar flow conditions.

M. For swing type check valves, locate valve a minimum of 10 pipe diameters downstream of a reciprocating pump or other turbulence inducing device such as an elbow or tee. Locate elbows, reductions, etc. a minimum of 5 pipe diameters downstream of valve.

N. For silent type check valves, locate valve a minimum of 4 pipe diameters downstream of a reciprocating pump or other turbulence inducing device such as an elbow or tee. Locate elbows, reductions, etc. a minimum of 3 pipe diameters downstream of valve.

O. Valves installed in copper lines shall be provided with screwed or flanged adapters with a union installed downstream and within 12" of the valve.

P. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to

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the outdoors; and pipe drain to nearest floor drain or as indicated on the Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, for installation requirements.

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 SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

3.5 HVAC SYSTEMS (HEATING WATER, CHILLED WATER, CONDENSER WATER, MAKE-UP WATER, AND COOLING COIL CONDENSATE DRAIN) WITH OPERATING TEMPERATURES UP TO 200°F.

A. Pipe NPS 2 and Smaller:

1. Shutoff: Ball Valves.
2. Prevent Backflow: Lift Check Valves or Bronze Swing Check Valves.
3. Regulate/Balance Flow: Calibrated Ball Type or Venturi Combination Balancing Shutoff Valves.

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

1. Shutoff: Butterfly Valves.
2. Prevent Backflow: Iron Swing Check Valves or Globe Body Silent Check Valves.
3. Regulate/Balance Flow: Venturi Butterfly or Venturi Globe Type Combination Balancing and Shutoff Valves.

3.6 HVAC SYSTEMS (LOW PRESSURE STEAM AND CONDENSATE) WITH OPERATING PRESSURE UP TO 15 PSIG AND TEMPERATURE UP TO 250°F.

A. Pipe NPS 2 and Smaller:

1. Shutoff: Bronze Gate Valves.
2. Prevent Backflow: Bronze Swing Check Valves.
3. Regulate/Balance Flow: Bronze Globe Valves.

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

1. Shutoff: Iron Gate Valves.
2. Prevent Backflow: Iron Swing Check Valves.
3. Regulate/Balance Flow: Iron Globe Valves.

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3.7 HVAC SYSTEMS (HIGH PRESSURE STEAM AND CONDENSATE OR HIGH TEMPERATURE HOT WATER) WITH OPERATING PRESSURE UP TO 125 PSIG AND TEMPERATURES UP TO 400°F.

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

1. Shutoff: Forged Carbon Steel Gate Valves (Class 300).
2. Prevent Backflow: Piston Type Check Valves (Class 300).
3. Regulate/Balance Flow: Forged Steel Globe Valves (Class 300).

B. Pipe Sizes NPS 2 and Larger:

1. Shutoff: Cast Steel Gate Valves.
2. Prevent Backflow: Cast Steel Swing Check Valves.
3. Regulate/Balance Flow: Cast Steel Globe Valves.

3.8 HVAC SYSTEMS (HIGH PRESSURE STEAM AND CONDENSATE OR HIGH TEMPERATURE HOT WATER) WITH OPERATING PRESSURE UP TO 400 PSIG AND TEMPERATURE UP TO 500°F.

A. All Pipe Sizes:

1. Shutoff: Forged Carbon Steel Gate Valves (Class 600).
2. Prevent Backflow: Piston Type Check Valves (Class 600).
3. Regulate/Balance Flow: Forged Steel Globe Valves (Class 600).

END OF SECTION 23 05 23

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SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports.
2. Pipe Stands.
3. Pipe Support Accessories.
4. Flashing.
5. Equipment curbs.
6. Formed steel channel.
7. Equipment bases and supports.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME B31.1 - Power Piping.
2. ASME B31.5 - Refrigeration Piping.
3. ASME B31.9 - Building Services Piping.

B. ASTM International:

1. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
2. ASTM E814 - Standard Test Method for Fire Tests of Through Penetration Fire Stops.
3. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
4. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.

C. American Welding Society:

1. AWS D1.1 - Structural Welding Code - Steel.

D. FM Global:

1. FM - Approval Guide, A Guide to Equipment, Materials and Services Approved By Factory Mutual Research For Property Conservation.

E. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
3. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

F. Underwriters Laboratories Inc.:

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1. UL 263 - Fire Tests of Building Construction and Materials.
2. UL 723 - Tests for Surface Burning Characteristics of Building Materials.
3. UL 1479 - Fire Tests of Through-Penetration Firestops.
4. UL 2079 - Tests for Fire Resistance of Building Joint Systems.
5. UL - Fire Resistance Directory.

G. Intertek Testing Services (Warnock Hersey Listed):

1. WH - Certification Listings.

1.3 DEFINITIONS

A. Firestopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire rated construction.

1.4 PERFORMANCE REQUIREMENTS

A. Firestopping Materials: Comply with requirements of Section 078400.

1.5 SUBMITTALS

A. Section 013300 - Submittal Procedures: Submittal procedures.

B. Action Submittals:

1. Shop Drawings: Indicate system layout with location including critical dimensions, sizes, and pipe hanger and support locations and detail of trapeze hangers.
2. Product Data: Submit manufacturers catalog data including load capacity for all hangers, supports, stands, rods, and structural channel products.
3. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers. Indicate calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers. Submit sizing methods sealed by a registered professional engineer.
4. Manufacturer's Installation Instructions:

    a. Hangers and Supports: Submit special procedures and assembly of components.
    b. Firestopping: Submit preparation and installation instructions.

5. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

C. Informational Submittals:

1. Welding Certificates.
2. Operational and Maintenance Data for all products installed.

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1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience or as approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

C. Protect from weather and construction traffic, dirt, water, chemical, and damage, by storing in original packaging.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Section 016000 - Product Requirements: Environmental conditions affecting products on site.

B. Provide ventilation in areas to receive solvent cured materials.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Acceptable Manufacturers: Acceptable Manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Anvil International
2. B-Line Systems
3. Empire Industries, Inc.
4. ERICO/Michigan Hanger Co.
5. Globe Pipe Hanger Products
6. Grinnel Corp.
7. Hilti
8. National Pipe Hanger Corp.
9. PHD Manufacturing, Inc.

B. General Descriptions:

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1. Carbon-Steel Pipe Hangers and Supports

    a. Factory fabricated, galvanized Carbon-steel MSS SP-58, Types 1 through 58, pipe hangers.
    b. Plastic Coated, Jacketed, or lined as required.
    c. Padded with fiberglass or other pipe insulation pad or cushioning to support bearing surface of piping.

2. Saddles:

    a. Galvanized steel, 180 degree shaped, marked with insulation outside diameter.
    b. Standard manufacturer's size to correspond to insulated pipe size.

3. Copper Pipe Hangers

    a. Factory fabricated, copper-coated-steel MSS SP-58, Types 1 through 58

4. Trapeze Pipe Hangers:

    a. Shop or Field Fabricated pipe support assembly compliant with MSS SP-69, Type 59, made rom structural carbon steel shapes and hanger rods, nuts, saddles, and U-Bolts compliant with MSS SP-58.

C. Hydronic Piping hangers:

1. Conform to ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Carbon steel, adjustable swivel, split ring.
3. Hangers for Cold Pipe Sizes 2 inch and Larger: Carbon steel, adjustable, clevis.
4. Hangers for Hot Pipe Sizes 2 to 4 inch: Carbon steel, adjustable, clevis.
5. Hangers for Hot Pipe Sizes 6 inch and Larger: Adjustable steel yoke, cast iron roll, double hanger.
6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 inches (150 mm) and Larger: Steel channels with welded spacers and hanger rods, cast iron roll.
8. Wall Support for Pipe Sizes 3 inches (76 mm) and Smaller: Cast iron hooks.
9. Wall Support for Pipe Sizes 4 inch and Larger: Welded steel bracket and wrought steel clamp.
10. Wall Support for Hot Pipe Sizes 6 inch and Larger: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
11. Vertical Support: Steel riser clamp.
12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes 4 inch and Smaller: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
14. Floor Support for Hot Pipe Sizes 6 inches and Larger: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Copper Pipe Support: Copper-plated, carbon steel ring.
16. .

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D. Refrigerant Piping Hangers:

1. Conform to ASME B31.5, ASTM F708, MSS SP58, MSS SP69, and MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Carbon steel, adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 inch and Larger: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods or approved structural strut product.
5. Wall Support for Pipe Sizes 3 inch and Smaller: Cast iron hook.
6. Wall Support for Pipe Sizes 4 inch and Larger: Welded steel bracket and wrought steel clamp.
7. Vertical Support: Steel riser clamp.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
9. Copper Pipe Support: Copper-plated carbon-steel ring.

2.2 PIPE STANDS

A. General Description: Shop or field fabricated assemblies made of corrosion resistant components to support roof or ground mounted piping.

B. Low-type, Single-Pipe Stand: One-piece plastic, stainless steel, or rubber base unit with a plastic roller for installation on a roof without penetrating the membrane. Include roof pads between stand and membrane.

C. High-Type, Single- or Multiple-Pipe Stands: Base or Assembly of bases, vertical and horizontal members, pipe supports, and pipe support accessories for hanging or setting pipe on a roof without penetrating a membrane.

1. Plastic, stainless steel, or rubber base, one or more.
2. Two or more vertical structural steel or channel, protectively coated.
3. Two or more horizontal structural steel or channel, protectively coated.
4. Pipe supports set on top of bottom horizontal member or hung from top horizontal member.

D. Curb Mounted Stands: Shop- or Field-fabricated pipe supports made from structural steel or channel, threaded rods, rollers, and other pipe hangers and accessories, mounted on a permanent, stationary roof curb.

2.3 PIPE SUPPORT ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

B. Thermal Shield Inserts

1. Cold Pipe: ASTM C 552 Type II Cellular glass with 100-PSIG or ASTM C 591, Type VI Grade I polyisocyanurate with 125 PSIG minimum compressive strength vapor barrier.
2. Hot Pipe: Water repellant treated, ASTM C 533, Type I Calcium silicate with 100-PSIG ASTM C 552, Type II cellular glass with 100 PSIG, or ASTM C 591, Type VI, Grade I, polyisocyanurate with 125-PSIG minimum compressive strength.

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3. Metal shield shall cover lower 180 degrees of pipe in clevis and band hangers, full pipe circumference for pipe in trapeze and clamp hangers.
4. Insert shall extend a minimum of 2 inches beyond shield metal shield.

2.3 FLASHING

A. Metal Flashing: Minimum 26 gage thick galvanized steel unless otherwise indicated by the Architectural specifications and details.

B. Metal Counterflashing: Minimum 22 gage thick galvanized steel unless otherwise indicated by the Architectural specifications and details.

C. Flexible Flashing: Minimum 47 mil thick sheet unless otherwise indicated by the Architectural specifications and details, compatible with roofing.

D. Caps: Steel, minimum thickness 22 gage minimum; minimum thickness 16 gage at fire resistant elements.

2.4 EQUIPMENT CURBS

A. Acceptable Manufacturers: To all feasible extents, utilize the equipment manufacture’s curbs. When a third-party curb is required, then select from the Acceptable Manufacturers listed below. Other manufacturers of equivalent products may be submitted for review.

1. LM Curbs
2. Metal Form Manufacturing
3. Pate Company
4. Roof Products, Inc.

B. Fabrication: Welded 18 gage galvanized steel shell and base, mitered 3 inch cant, minimum 1-inch insulation, glued and pinned.

2.5 FORMED STEEL CHANNEL

A. Acceptable Manufacturers: Acceptable Manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Unistrut
2. B-line by Eaton
3. Hilti

B. Product Description: Galvanized 12 gage thick steel with holes at regular intervals, 2-inch or less, on center.

2.6 FIRESTOPPING

A. Firestopping Materials: Comply with requirements of Section 078400.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify openings are ready to receive sleeves.

C. Verify openings are ready to receive firestopping.

3.2 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.

B. Remove incompatible materials affecting bond.

C. Install damming materials to arrest liquid material leakage.

D. Obtain permission from Architect/Engineer before using powder-actuated anchors.

E. Do not drill or cut structural members.

3.3 INSTALLATION - INSERTS

A. Install inserts for placement in concrete forms.

B. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inch (100 mm) and larger.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.4 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Install in accordance with the same ASME B31 section as listed in common requirements, ASTM F708, MSS SP 58, MSS SP 69, and MSS SP 89.

B. Support horizontal piping as scheduled.

C. Install hangers with minimum 1/2 inch space between finished covering and adjacent work.

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D. Place hangers within 12 inches of each horizontal elbow.

E. Use hangers with 1-1/2 inch minimum vertical adjustment.

F. Support vertical piping at every floor.

G. Where piping is installed in parallel and at same elevation, provide multiple pipe or trapeze hangers.

H. Support riser piping independently of connected horizontal piping.

I. Provide copper plated hangers and supports for copper piping.

J. Design hangers for pipe movement without disengagement of supported pipe.

K. Prime coat exposed steel hangers and supports. Refer to Section 099000. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.5 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 4-inch-thick and extending 6 inches beyond supported equipment. Refer to Section 033000.

B. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.

C. Construct supports of steel members or formed steel channel. Brace and fasten with flanges bolted to structure.

D. Provide rigid anchors for pipes after vibration isolation components are installed. Refer to Section 210548.

3.6 INSTALLATION - FLASHING

A. Refer to Architectural specifications for Flashing and Waterproofing. When Architectural sections do not explicitly state requirements:

1. Provide flexible flashing and metal Counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
2. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms for sound control.
3. Provide curbs for roof installations 14 inch minimum high above roofing surface. Flash and counter-flash with sheet metal; seal watertight. Attach Counterflashing to equipment and lap base flashing on roof curbs. Flatten and solder joints.
4. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

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3.7 FIELD QUALITY CONTROL

A. Section 014000 - Quality Requirements: Requirements for inspecting, testing.

B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.

C. Inspect installed firestopping for compliance with specifications and submitted schedule.

3.8 CLEANING

A. Section 017000 - Execution and Closeout Requirements: Requirements for cleaning.

B. Clean adjacent surfaces of firestopping materials.

3.9 PROTECTION OF FINISHED WORK

A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.

B. Protect adjacent surfaces from damage by material installation.

3.10 SCHEDULES

A. Copper Tube Hanger Spacing:

1. Pipe Size 1-1/4 Inch and smaller:
   a. Maximum Horizontal Hanger Spacing: 6 feet.
   b. Maximum Vertical Spacing: 10 feet or at each floor penetration.
   c. Hanger Rod Diameter: 3/8 inch.

2. Pipe Size 1-1/2 Inch and larger
   a. Maximum Horizontal Hanger Spacing: 10 feet.
   b. Maximum Vertical Spacing: 10 feet or at each floor penetration.
   c. Hanger Rod Diameter: 1/2 inch.

B. Steel Pipe Hanger Spacing:

1. Pipe Size 3 inch and smaller:
   a. Maximum Horizontal Hanger Spacing: 10 feet.
   b. Maximum Vertical Spacing: 15 feet or at each floor penetration.
   c. Minimum Hanger Rod Diameter: 1/2 inch.

2. Pipe Size over 3 inch and under 6 inch:

   a. Maximum Horizontal Hanger Spacing: 12 feet.
   b. Maximum Vertical Spacing: 15 feet or at each floor penetration.
   c. Minimum Hanger Rod Diameter: 5/8 inch.

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3. Pipe Size 6 inch and over but and under 10 inch:

    a. Maximum Hanger Spacing: 12 feet.
    b. Maximum Horizontal Vertical Spacing: 15 feet or at each floor penetration.
    c. Minimum Hanger Rod Diameter: 3/4 inch.

4. Pipe Size 10 inch and over but under 14 inch:

    a. Maximum Hanger Spacing: 12 feet.
    b. Maximum Horizontal Vertical Spacing: 15 feet or at each floor penetration.
    c. Minimum Hanger Rod Diameter: 7/8 inch.

5. Pipe Size 14 inch and over but under 20 inch:

    a. Maximum Hanger Spacing: 12 feet.
    b. Maximum Horizontal Vertical Spacing: 15 feet or at each floor penetration.
    c. Minimum Hanger Rod Diameter: 1 inch.

C. Plastic Pipe Hanger Spacing:

1. Pipe Material: ABS.

    a. Maximum Horizontal Hanger Spacing: 4 feet.
    b. Maximum Vertical Support Spacing: 10 feet or at each floor penetration.
    c. Minimum Hanger Rod Diameter: 1/2 inch.

2. Pipe Material: FRP.

    a. Maximum Horizontal Hanger Spacing: 4 feet.
    b. Maximum Vertical Support Spacing: 10 feet or at each floor penetration.
    c. Minimum Hanger Rod Diameter: 1/2 inch.

3. Pipe Material: PVC.

    a. Maximum Horizontal Hanger Spacing: 4 feet.
    b. Maximum Vertical Support Spacing: 10 feet or at each floor penetration.
    c. Minimum Hanger Rod Diameter: 1/2 inch.

END OF SECTION 230529

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SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes vibration and seismic isolation devices for HVAC.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.

a. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

1) Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction
2) Annotate to indicate application of each product submitted and compliance with requirements.

c. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

2. Shop Drawings:

a. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

3. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

a. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements,

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design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

b. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind (where applicable) restraints and for designing vibration isolation bases.

1) Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

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

d. Seismic and Wind-Restraint Details:

1) Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
2) Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
3) Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
4) 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).

B. Informational Submittals:

1. 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.
2. Qualification Data: For professional engineer.
3. Welding certificates.
4. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading: Refer to Drawings.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Kinetics Noise Control, Inc.
    b. Mason Industries, Inc.
    c. Novia; A Division of C&P.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Smooth, ribbed, or waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Kinetics Noise Control, Inc.

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b. Mason Industries, Inc.
c. Novia; A Division of C&P.

2. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.
c. Novia; A Division of C&P.

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:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.
c. Novia; A Division of C&P.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

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5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. 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.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Kinetics Noise Control, Inc.
    b. Mason Industries, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with attachment and leveling bolt.

2.7 RESTRAINED-SPRING ISOLATORS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Kinetics Noise Control, Inc.
    b. Mason Industries, Inc.
    c. Novia; A Division of C&P.

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 holes.

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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.

2.8 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, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.

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 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.

2.9 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig isolation material providing equal isolation in all directions.

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2.10 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.
c. Novia; A Division of C&P.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.

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

2.12 SPRING HANGERS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Kinetics Noise Control, Inc.
b. Mason Industries, Inc.
c. Novia; A Division of C&P.

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.

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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.

2.13 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Novia; A Division of C&P.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.14 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut; Part of Atkore International.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

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2.15 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Novia; A Division of C&P.

B. Restraint Cables: ASTM A 492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.16 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Novia; A Division of C&P.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.17 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. B-line, an Eaton business.
2. Hilti, Inc.

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3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.18 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: 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 E 488.

2.19 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Novia; A Division of C&P.

B. 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. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall 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.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

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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. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall 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. 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: Low mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall 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, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Novia; A Division of C&P.
4. Pate Company, The.
5. Thybar Corporation.

B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.

D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

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E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. 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 counter flashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind-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 hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 3 Sections.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Division 7 Sections for installation of roof curbs, equipment supports, and roof penetrations.

D. 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.

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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.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet on center, and longitudinal supports a maximum of 80 feet on center or as required by authority having jurisdiction.
3. Brace piping longer than 12 feet after a change of direction.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

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

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate

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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 other Division 23 Sections for piping flexible connections.

3.5 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Engineer, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' notice.
3. Obtain Engineer’s approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

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

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 3 Sections.

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SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Valve tags.
6. Warning tags.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.
2. Samples: For color, letter style, and graphic representation required for each identification material and device.
3. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
4. Valve numbering scheme.

B. Closeout Submittals:

1. Valve Schedules: For each piping system to include in operation and maintenance data.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass: 0.032-inch, stainless steel: 0.025-inch, aluminum: 0.032-inch, or anodized aluminum: 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.

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5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

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

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

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2.5 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: 0.032-inch, stainless steel: 0.025-inch, aluminum: 0.032-inch, or anodized aluminum: 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

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3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve or control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:

1. Chilled-Water Piping:

   a. Background Color: Green.
   b. Letter Color: White.

2. Condenser-Water Piping:

   a. Background Color: Green.
   b. Letter Color: White.

3. Heating Water Piping:

   a. Background Color: Green.
   b. Letter Color: White

4. Refrigerant Piping:

   a. Background Color: Green.
   b. Letter Color: White.

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3.5 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air and variable temperature supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape: 1-1/2 inches, round.
2. Valve-Tag Colors: Natural.
3. Letter Color: Black.

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing air systems.
2. Balancing hydronic water piping systems.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TAB Specialist: An entity engaged to perform TAB Work.

1.3 SUBMITTALS

A. Action Submittals:

1. Certified TAB reports.

B. Informational Submittals:

1. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
2. Contract Documents Examination Report: Within 45 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
3. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

1.4 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC or NEBB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
2. TAB Technician: Employee of the TAB contractor and certified by AABC or NEBB as a TAB technician.

B. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

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2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard AABC or NEBB TAB forms.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.5 COORDINATION

A. Notice: Provide at least seven days' notice before each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.6 HVAC CONTRACTOR RESPONSIBILITIES

A. Provide TAB agency one complete set of contract documents, change orders, and approved submittals in digital pdf format.

B. Control contractor shall provide required BAS hardware, software, personnel, and assistance to TAB agency as required for TAB agency to balance the systems. Control contractor shall also provide trending reports as needed to demonstrate that systems are complete.

C. Coordinate meetings and assistance from suppliers and contractors as required by TAB agency.

D. Provide additional valves, dampers, sheaves and belts as required by TAB agency.

E. Flag all manual volume dampers with high-visibility tape.

F. Provide access to all dampers, valves, test ports, nameplates, and other appurtenances as required by TAB agency.

G. Remove and replace or repair insulation as needed to provide access for the TAB work.

H. Have the HVAC systems at complete operational readiness before TAB begins.

I. Promptly correct deficiencies identified during TAB.

J. Maintain a construction schedule that allows the TAB agency to complete work prior to occupancy.

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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 systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that these balancing devices 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 systems and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenums are sealed (and fire-stopped if required).

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 might cause reduced capacities.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment under actual installed conditions. Use tables and charts in AMCA 201, "Fans and Systems" or in SMACNA "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 filters and verify that bearings are greased, belts are aligned and tight, clean filters are installed, and equipment with functioning controls is ready for operation.

J. Examine terminal units, verifying that they are accessible and that their controls are connected, configured by the control contractor, and functioning.

K. Examine two-way control valves for proper installation and function.

L. Examine three-way valves for proper installation for their intended uses of diverting or mixing fluid flows and for proper function.

M. Examine all equipment items to verify correct piping arrangements.

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N. Examine heat-transfer coils for correct piping connections and for clean and properly-spaced fins.

O. 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:

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 each equipment item.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. General:

a. Electrical power wiring is complete.
b. Control systems are operational.
c. Access is provided to balancing and control devices.
d. Variable frequency drive start-up procedures are complete.
e. Safety devices are operational and indicating normal status.

2. Air Side:

a. Ductwork is complete with air terminals installed.
b. Balance, fire, and smoke dampers are open and operational.
c. Control dampers are in their normal (fail) positions.
d. Equipment and duct access doors are securely closed.
e. Clean filters are installed.
f. Fans are operating and rotating in correct directions.
g. Fan vibration levels are within tolerance limits.
h. Building envelope is complete, and exterior windows and doors are closed.

3. Hydronics:

a. Piping is complete with all terminal units installed.
b. Systems are flushed, filled, and purged of free air.
c. Strainers are clean, and startup strainer screens are removed.
d. Water treatment is complete.
e. Isolation and balance valves are open and operational. Drain valves are closed.
f. Control valves are in their normal (fail) positions.
g. Pumps are operating and rotating in correct directions.
h. Pump vibration levels are within tolerance limits.

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3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC "National Standards for Total System Balance" or NEBB "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
2. Install new insulation where insulation is removed for TAB to match removed materials. Restore insulation, coverings, vapor barrier, and finish.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control devices, 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 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 system "as-built" duct layouts with all components identified.

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. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check condensate drains for proper connections and function.

H. Check for proper sealing of air-handling-unit components.

3.5 PROCEDURES FOR CONSTANT-VOLUME AND VARIABLE-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 as follows:

   a. Set outdoor air, return air, and relief air dampers for proper positions that simulate minimum outdoor air conditions.
   b. Where conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.

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c. Where conditions are not suitable for duct Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. Where sufficient space is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow. Measure fan static pressures as follows:

a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the discharge flexible connection.
c. Measure inlet static pressure of single-inlet fan at the fan inlet or through the inlet flexible connection.
d. Measure inlet static pressure of double-inlet fan through the wall of the plenum that houses the fan or through the inlet flexible connections.

3. Measure static pressure across each component that makes up the air-handling unit, rooftop unit, or other air-handling equipment. Report the cleanliness status of filters and the time static pressures are measured. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
4. Adjust fan speed higher or lower than indicated speed as needed to achieve indicated air-handling-unit performance.
5. 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 will occur. 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 ducts to indicated airflows within specified tolerances.

1. Measure airflows of branch ducts.
2. Adjust branch duct balance dampers for specified airflows.
3. Re-measure each branch duct after all have been adjusted.

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

1. Adjust each outlet in same room or space to indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.
3. Measure airflows at all inlets and outlets.
4. Adjust each inlet and outlet for specified airflow.
5. Re-measure each inlet and outlet after all have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm minimum outdoor air, return air, and relief air flow rates are within design tolerances. Readjust as necessary.
2. Re-measure and confirm total airflow is within design tolerance.
3. Re-measure all final fan operating data. Include fan speeds, motor voltages, motor amperages, and static profiles.

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4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation; adjust if necessary. Measure and record all operating data.
6. Record final performance data.

3.6 ADDITIONAL PROCEDURES FOR VARIABLE- VOLUME AIR SYSTEMS

A. Variable-Air-Volume Systems: Adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Verify that the duct static pressure sensors are installed and controlling the system.
3. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure inlet static pressure. Adjust system static pressure 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 terminal unit is calling for maximum airflow. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor. When maximum airflow is correct, balance the air outlets downstream from the terminal unit.
    b. Adjust controls so terminal is calling for minimum airflow. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. Note any deviation from design airflow.

5. After all terminal units 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 the fan manufacturer.

    a. Set outdoor 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 airflows so connected total matches fan selection and simulates actual load in the building.

6. Measure fan static pressure. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outdoor airflow rates to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Balance the return air ducts and inlets as described for constant-volume air systems.
    b. Verify all terminal units are meeting design airflow rates under system maximum airflow conditions.

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8. Re-measure the inlet static pressure at the most critical air terminal unit and adjust the system static pressure setpoint to the most energy-efficient setpoint to maintain optimum system static pressure. Record setpoint.

9. Re-measure the final system conditions as follows:

   a. Re-measure and confirm minimum outdoor air, return air, and relief air flow rates are within design parameters. Readjust to design if necessary.
   b. Re-measure and confirm total airflow rates are within design parameters.
   c. Re-measure all final fan operating data.
   d. Mark all 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.
   g. Record final performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations beyond specified tolerances.

B. Prepare schematic diagrams of system "as-built" piping layouts.

C. Verify that hydronic systems are ready for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Check that makeup water has adequate pressure to highest vent.
2. Check that air has been purged from the system.
3. Open isolation and balance valves. Close drain valves.
4. Check motorized valves for specified sequence of operation, and set at indicated flow rates.
5. Set differential-pressure control valves at the specified differential pressures. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Check pump-motor loads. If motors are overloaded, throttle flow so motor nameplate rating is not exceeded.
7. Verify that motor starters are equipped with properly sized overload protection.

3.8 PROCEDURES FOR CONSTANT-FLOW AND VARIABLE-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design flow rates.

1. Measure total water flow.

   a. Position valves for full flow through heat exchangers.
   b. Measure flow rate by main flow meter (if provided).
   c. If no main flow meter is provided, determine flow by pump total dynamic head (TDH) or heat exchanger pressure drop.

2. Measure pump TDH as follows:

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a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe downstream from any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
e. With all valves open, read pump TDH. Adjust pump discharge valve or variable-speed drive until design water flow rate is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
4. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
5. Report flow rates that are not within plus or minus 10 percent of design.

B. Adjust flow measuring devices installed in main and branch piping to design flow rates.

1. Measure flow rates in main and branch lines.
2. Adjust main and branch balance valves for design flow rates.
3. Re-measure each valve after all have been adjusted.

C. Adjust flow measuring device installed at each terminal heat exchanger to design flow rate.

1. Measure flow rate at each terminal heat exchanger.
2. Adjust each terminal heat exchanger to design flow rate.
3. Re-measure each terminal heat exchanger flow rate after all have been adjusted.
4. Position each three-way heat exchanger control valve to bypass heat exchanger, and adjust the bypass balance valve to maintain design flow rate.
5. Perform temperature tests after all flow rates have been balanced.

D. For systems with pressure-independent balance valves at terminal heat exchangers:

1. Measure each balance valve differential pressure and verify that it is within tolerances.
2. Perform temperature tests after all flow rates have been verified.

E. For systems with pressure-dependent balance valves or flow-measuring devices at terminal heat exchangers:

1. Measure and balance heat exchanger flow rates by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after all flow rates have been verified.

F. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

G. Verify final system conditions as follows:

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1. Re-measure and confirm that total water flow rates are within design parameters.
2. Re-measure final pump operating data.
3. Mark all final settings.

H. Verify that all memory stops have been set.

I. Check settings and operation of each safety valve. Record settings.

3.9 ADDITIONAL PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Adjust variable-flow hydronic systems as follows:

1. Verify that the differential pressure sensor is located per the contract documents.
2. Determine if there is diversity in the system.

B. For systems with no diversity:

1. Follow procedures outlined above for constant-flow hydronic systems.
2. Prior to verifying final system conditions, determine the system differential pressure setpoint.
3. If a pump discharge valve was used to set total system flow with the pump VFD at 60 Hz, at completion open discharge valve fully and allow VFD to control system differential pressure setpoint. Record pump data under both conditions.
4. Mark all final settings and verify that all memory stops have been set.

C. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves to approximate the maximum flow rate. Balance the flow rates for the terminals with open control valves.
3. Follow procedures outlined above for constant-flow hydronic systems.
4. Open all the control valves that were shut, and close enough control valves that were previously open to again approximate the maximum flow rate. Balance the flow rates for the terminals with open control valves.
5. Prior to verifying the final system conditions, determine the system differential pressure setpoint.
6. If a pump discharge valve was used to set total system flow with the VFD at 60 Hz, at completion open discharge valve fully and allow VFD to control system differential pressure setpoint. Record pump data under both conditions.
7. Mark all final settings and verify that all memory stops have been set.

3.10 PROCEDURE FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits. Follow the above procedures.

3.11 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

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1. Supply, Return, and Exhaust Fans and Other Equipment with Fans: Plus or minus 5 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Hydronic Water Flow Rate: Plus or minus 5 percent.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into a separate section for each tested and balanced system. Provide a final report that is a complete record of the HVAC system performance, including conditions of operation, any outstanding items, and any deviations found during the testing and balancing process. The final report is to provide a reference of actual operating conditions for the owner and operations personnel. All measurements and test results that appear in the report must be made on site and dated by the responsible technician or test and balance engineer.

B. As a minimum the report shall include the following information:

1. Title page, including:

   a. TAB company name, address, and telephone number.
   b. Project name, client, identification number, and location.
   c. Project architectural firm, address, and telephone number.
   d. Project HVAC engineering firm, address, and telephone number.
   e. Project HVAC contracting firm, address, and telephone number.
   f. TAB certification statement.
   g. Test and balance engineer name, signature, and certification number.
   h. Report date.

2. Table of contents.
3. TAB national performance guarantee.
4. Report summary, including:

   a. List of items that do not meet specified tolerances.
   b. Information that may be considered in resolving deficiencies.

5. Instrument list, including:

   a. Type.
   b. Manufacturer.
   c. Model.
   d. Serial number.
   e. Calibration date.

C. TAB test data for all systems included in the Work.

3.13 INSPECTIONS

A. Initial Inspection:

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1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:

   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least 5 percent of terminals.
   c. Measure room temperature at each thermostat or temperature sensor. Compare the reading to the set point.
   d. Verify that balancing devices are marked with final balance positions.
   e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner's Representative.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Owner's Representative.
3. Owner's Representative shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to 10 percent of the total measurements recorded.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and adjust. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's payment.

D. Prepare test and inspection reports.

3.14 SCHEDULE

A. Provide hydronic and air balancing for each of the following equipment items as part of this work. Note that listing an item of equipment includes any motors, valves, dampers, and filters associated with that equipment:

1. Control valves
2. Control dampers
3. Pumps
   a. Heating water

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b. Chilled water
4. Air terminal units
a. Fans
b. Coils
c. Control Dampers and Valves
d. Energy Recovery Devices
5. Air outlets and inlets
6. Power and Gravity ventilators
a. Exhaust fans
b. Pod exhaust fans
c. Louvered Penthouses
7. Kitchen hoods
8. Refrigerant condensing units
9. Chillers
10. Air-handling units
11. Packaged HVAC units
12. Ductless Split Systems
13. Fan coil units
14. Electric Unit heaters
15. Hydronic radiant heaters (Cabinet and Propeller)
16. Gas-fired radiant heaters

END OF SECTION 23 05 93

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SECTION 23 07 13 - HVAC DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes duct insulation and appurtenances.

1.2 SUBMITTALS

A. Action Submittals:

1. 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. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Protection: Do not permit mineral fiber insulation to get wet. Mineral fiber insulation that is or has been wet shall be removed from the project site.

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with duct Installer for duct insulation application. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

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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 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. K-Flex USA.

2. Properties:

a. Maximum Operating Temperature: 180 deg F.
b. Minimum Operating Temperature: -70 deg F.
c. Maximum Thermal Conductivity at 75 deg F Mean Temperature: Thickness 1 Inch or Less: 0.245 Btu-in/hr-ft^2-deg F.
d. Maximum Water Vapor Permeability Thickness 1 Inch or Less: 0.05 perm-inches.
e. Maximum Water Absorption by Volume: 0.2%.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin in a flexible blanket. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

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a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Atmosphere Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR Duct Wrap FRK.

2. Properties:

a. Maximum Operating Temperature: 250 deg F.
b. Maximum Compressed Thermal Conductivity at 75 deg F Mean Temperature:

1) Density 0.75 PCF: 0.29 Btu-in/hr-ft^2-deg F.
2) Density 1.0 PCF: 0.27 Btu-in/hr-ft^2-deg F.
3) Density 1.5 PCF: 0.24 Btu-in/hr-ft^2-deg F.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin in a semi-rigid board. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ or with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. CertainTeed Corp.; CertaPro Commercial Board.
b. Johns Manville; 800 Series Spin-Glas.
c. Knauf Insulation; Earthwool Insulation Board.
d. Manson Insulation Inc.; AK Board.
e. Owens Corning; Fiberglas 700 Series.

2. Properties:

a. Maximum Operating Temperature: 450 deg F.
b. Minimum Operating Temperature: 0 deg F.
c. Maximum Thermal Conductivity at 75 deg F Mean Temperature:

1) Density 3.0 PCF: 0.23 Btu-in/hr-ft^2-deg F.
2) Density 6.0 PCF: 0.23 Btu-in/hr-ft^2-deg F.

d. Minimum Compressive Strength at 10% Deformation:

1) Density 3.0 PCF: 25 lb/ft^2.
2) Density 6.0 PCF: 200 lb/ft^2.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

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B. For indoor applications, adhesives shall have VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

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

F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
2. Service Temperature Range: 0 to 180 deg F.
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

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1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

B. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system specifications indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. All-Service Jacket (ASJ): White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I. Maximum water vapor permeance 0.02 perms.
2. All-Service Jacket – Self-Sealing Lap (ASJ-SSL): ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I. Maximum water vapor permeance 0.02 perms.
3. Foil-Scrim Kraft (FSK) Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II. Maximum water vapor permeance 0.02 perms.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

2.8 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

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2.9 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

1. Color: White unless indicated otherwise.

B. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   a. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.
   b. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn].

2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
   a. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.
   b. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.

C. Self-Adhesive Indoor or Outdoor Jacket: Multiple-ply laminated vapor barrier and waterproofing membrane for installation over insulation; consisting of aluminum, Tedlar, or laminate sheet with integral acrylic peel-and-stick adhesive with white, silver, or black facing as indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

   a. 3M; VentureClad.
   b. Polyguard Products, Inc.; Alumaguard 60.

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.

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3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation in accordance with manufacturers' instructions.

B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

C. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system.

D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Install insulation with longitudinal seams at top and bottom of horizontal runs.

F. Install multiple layers of insulation with longitudinal and end seams staggered.

G. Keep insulation materials dry during application and finishing. Mineral fiber insulation that is or has been wet shall be removed from the job site.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on center
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 4 inches on center

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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.

M. Cut insulation in a manner to avoid compressing insulation to less than 75 percent of its nominal thickness.

N. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

E. Insulation Installation at Floor Penetrations:

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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.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket or Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to all surfaces of ducts, fittings, and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches on center
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches on center each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not over compress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with outward-clinching staples, 1 inch on center Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

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5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches on center.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. For board insulation, groove and score insulation to fit to outside and inside radii of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches on center.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches on center and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies.

3.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in painting specifications.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

    a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

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D. Do not field paint aluminum or stainless-steel jackets.

3.10 INDOOR DUCT INSULATION SCHEDULE

A. Supply air, concealed from view, round or oval, duct insulation:

1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

B. Supply air, exposed to view in unfinished space, round or oval, duct insulation:

1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

C. Supply air, exposed to view in finished space, round or oval, duct insulation:

1. Flexible Elastomeric: 1-1/2 inches thick with 20 mil PVC jacket.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density with 20 mil PVC jacket.
3. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density with 20 mil PVC jacket.

D. Supply air, concealed from view, rectangular, duct insulation:

1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

E. Supply air, exposed to view in unfinished space, rectangular, duct insulation:

1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

F. Supply air, exposed to view in finished space, rectangular, duct insulation:

1. Flexible Elastomeric: 1-1/2 inches thick with 20 mil PVC jacket.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density with 20 mil PVC jacket.
3. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density with 20 mil PVC jacket or finish-painted ASJ.

G. Return air or mixed air, concealed from view, round or oval, duct insulation, **and Exhaust Air Associated with DOAS-1 AND DOAS-2**

1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

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H. Return air or mixed air, exposed to view in unfinished space, round or oval, duct insulation, **and Exhaust Air Associated with DOAS-1 AND DOAS-2**

1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

I. Return air or mixed air, exposed to view in finished space, round or oval, duct insulation: None.

J. Return air or mixed air, concealed from view, rectangular, duct insulation, **and Exhaust Air Associated with DOAS-1 AND DOAS-2**
1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

K. Return air or mixed air, exposed to view in unfinished space, rectangular, duct insulation, **and Exhaust Air Associated with DOAS-1 AND DOAS-2**

1. Flexible Elastomeric: 1-1/2 inches thick.
2. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

L. Return air or mixed air, exposed to view in finished space, rectangular, duct insulation, **and Exhaust Air Associated with DOAS-1 AND DOAS-2**
1. Flexible Elastomeric: 1 inch thick with 20 mil PVC jacket.
2. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density with 20 mil PVC jacket or finish-painted ASJ.

M. Relief air or transfer air, any indoor location, duct insulation: None unless lined for acoustics.

N. Outdoor air or combustion air, concealed from view, round or oval, duct insulation:

1. Flexible Elastomeric: 2 inches thick.
2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density.

O. Outdoor air or combustion air, exposed to view in unfinished space, round or oval, duct insulation:

1. Flexible Elastomeric: 2 inches thick.
2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density.

P. Outdoor air or combustion air, exposed to view in finished space, round or oval, duct insulation:

1. Flexible Elastomeric: 2 inches thick with 20 mil PVC jacket.
2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density with 20 mil PVC jacket.
3. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density with 20 mil PVC jacket.

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Q. Outdoor air or combustion air, concealed from view, rectangular, duct insulation:

1. Flexible Elastomeric: 2 inches thick.
2. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density.

R. Outdoor air or combustion air, exposed to view in unfinished space, rectangular, duct insulation:

1. Flexible Elastomeric: 2 inches thick.
2. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
3. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

S. Outdoor air or combustion air, exposed to view in finished space, rectangular, duct insulation:

1. Flexible Elastomeric: 2 inches thick with 20 mil PVC jacket.
2. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density with 20 mil PVC jacket.
3. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density with 20 mil PVC jacket or finish-painted ASJ.

3.11 OUTDOOR DUCT INSULATION SCHEDULE

A. Supply air, round or oval, duct insulation:

1. Flexible Elastomeric: 2 inches thick.

B. Supply air, rectangular, duct insulation:

1. Flexible Elastomeric: 2 inches thick.

C. Return air or mixed air, round or oval, duct insulation:

1. Flexible Elastomeric: 2 inches thick.

D. Return air or mixed air, rectangular, duct insulation:

1. Flexible Elastomeric: 2 inches thick.

E. Relief air or transfer air, any outdoor location, duct insulation: None.

F. Outdoor air or combustion air, any outdoor location, duct insulation: None.

G. Exhaust air (all classes), any outdoor location, duct insulation: None unless indicated otherwise.

H. Exhaust air (class 2 exhaust from shower or washdown area), any outdoor location, duct insulation:

1. Flexible Elastomeric: 2 inches thick.

END OF SECTION 23 07 13

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SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating HVAC piping systems.

1.2 SUBMITTALS

A. Action Submittals

1. 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. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Protection: Do not permit mineral fiber or calcium silicate insulation to get wet. Mineral fiber or calcium silicate insulation that is or has been wet shall be removed from the project site.

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping Installer for piping insulation application.

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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 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. K-Flex USA.

2. Properties:

a. Maximum Operating Temperature: 180 deg F.
b. Minimum Operating Temperature: -70 deg F.
c. Maximum Thermal Conductivity at 75 deg F Mean Temperature: Thickness 1 Inch or Less: 0.245 Btu-in/hr-ft^2-deg F.
d. Maximum Water Vapor Permeability Thickness 1 Inch or Less: 0.05 perm-inches.
e. Maximum Water Absorption by Volume: 0.2%.

F. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. CertainTeed Corp.
b. Johns Manville.
c. Knauf Insulation.

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d. Manson Insulation Inc.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

4. Properties:

a. Maximum Thermal Conductivity at 75 deg F Mean Temperature:

1) Density 3.0 PCF: 0.23 Btu-in/hr-ft^2-deg F.
2) Density 6.0 PCF: 0.23 Btu-in/hr-ft^2-deg F.

b. Minimum Compressive Strength at 10% Deformation:

1) Density 3.0 PCF: 25 lb/ft^2.
2) Density 6.0 PCF: 200 lb/ft^2.

G. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. CertainTeed Corp.
b. Johns Manville.
c. Knauf Insulation.
d. Manson Insulation Inc.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

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B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

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

E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
2. Service Temperature Range: 0 to 180 deg F.
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.

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2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. All-Service Jacket (ASJ): White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I. Maximum water vapor permeance 0.02 perms.
2. All-Service Jacket – Self-Sealing Lap (ASJ-SSL): ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I. Maximum water vapor permeance 0.02 perms.
3. Foil-Scrim Kraft (FSK) Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II. Maximum water vapor permeance 0.02 perms.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

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2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.
b. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.

2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper or2.5-mil-thick polysurlyn.
b. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper or 2.5-mil-thick polysurlyn.

C. Self-Adhesive Indoor or Outdoor Jacket: Multiple-ply laminated vapor barrier and waterproofing membrane for installation over insulation; consisting of aluminum, Tedlar, or laminate sheet with integral acrylic peel-and-stick adhesive with white, silver, or black facing as indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. 3M; VentureClad.
b. Polyguard Products, Inc.; Alumaguard 60.

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.
3. 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.

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B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation in accordance with manufacturers' instructions.

B. 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.

C. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system.

D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Install insulation with longitudinal seams at top and bottom of horizontal runs.

F. Install multiple layers of insulation with longitudinal and end seams staggered.

G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

H. Keep insulation materials dry during application and finishing. Mineral fiber or calcium silicate insulation that is or has been wet shall be removed from the job site.

I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

J. Install insulation with least number of joints practical.

K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

M. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

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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 on center.
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 on center.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

N. Cut insulation in a manner to avoid compressing insulation to less than 75 percent of its nominal thickness.

O. Repair joint separations and cracking due to thermal movement.

P. 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.

Q. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

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C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in firestopping section.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in firestopping section.

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.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, 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 or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is more. 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.

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5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is more. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is more.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, except for flexible elastomeric, 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.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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 shall conform 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 adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two 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.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

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B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-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 factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches on center.
4. For insulation with factory-applied 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 preformed 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 mineral-fiber blanket insulation.

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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 preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed 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 preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches on center and at end joints.

3.9 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as indicated. Vary first and second coats to allow visual inspection of the completed Work.

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D. Do not field paint aluminum or stainless-steel jackets.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Condensate or Equipment Drain Water Below 60 Deg F, or Makeup Water:

1. NPS 1-1/4 or Smaller: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1/2 inch thick.

2. NPS 1-1/2 or Larger: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.

B. Chilled Water or Brine, Above 40 Deg F:

1. NPS 1-1/4 or Smaller: Insulation shall be one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1/2 inch thick.

2. NPS 1-1/2 or Larger: Insulation shall be one of the following:

a. Cellular Glass: 2 inches thick.
b. Flexible Elastomeric: 1 inch thick.

C. Heating-Hot-Water Supply or Return, 200 Deg F or Below:

1. NPS 1-1/4 or Smaller: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inch thick.

2. NPS 1-1/2 or Larger: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

b. Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches thick.

D. Refrigerant Suction:

1. NPS 3/4 or Smaller: Insulation shall be the following:

a. Flexible Elastomeric: 1/2 inch thick.

2. NPS 1 to NPS 6: Insulation shall be the following:

a. Flexible Elastomeric: 1 inch thick.

3. NPS 8 or Larger: Insulation shall be the following:

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a. Flexible Elastomeric: 1-1/2 inches thick.

E. Refrigerant Hot-Gas:

1. NPS 1-1/4 or Smaller: Insulation shall be the following:

a. Flexible Elastomeric: 1 inch thick.

2. NPS 1-1/2 or Larger: Insulation shall be the following:

a. Flexible Elastomeric: 1-1/2 inches thick.

3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water or Brine:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 4 inches thick.
b. Flexible Elastomeric: 3 inches thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 3 inches thick.

B. Condenser-Water Supply or Return:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 3 inches thick.
b. Flexible Elastomeric: 2 inches thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

C. Refrigerant Suction:

1. NPS 3/4 or Smaller: Insulation shall be the following:

a. Flexible Elastomeric: 1 inch thick.

2. NPS 1 to NPS 6: Insulation shall be the following:

a. Flexible Elastomeric: 1-1/2 inches thick.

D. Refrigerant Hot-Gas:

1. NPS 1-1/4 or Smaller: Insulation shall be the following:

a. Flexible Elastomeric: 2 inches thick.

2. NPS 1-1/2 or Larger: Insulation shall be the following:

a. Flexible Elastomeric: 2-1/2 inches thick.

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3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed: None.

D. Piping, Exposed:

1. None.
2. PVC, Color-Coded by System: 20 mils thick.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

1. Aluminum, Smooth or Stucco Embossed with Z-Shaped Locking Seam: 0.032 inch thick.
2. Stainless Steel, Type 304 or 316, Smooth 2B Finish or Stucco Embossed with Z-Shaped Locking Seam: 0.020 inch thick.

END OF SECTION 23 07 19

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SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

1.2 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.3 SUBMITTALS

A. Informational Submittals:

1. Certificates of readiness.
2. Certificates of completion of installation, pre-start, and startup activities.

1.4 INSTRUMENTATION, TOOLS AND EQUIPMENT COSTS

A. The contractor is responsible for and shall include all labor, instrumentation, tools, and equipment costs required to perform the pre-functional, functional, owner training, and the development of all project manuals.

1.5 CONTRACTOR'S COMMISSIONING RESPONSIBILITIES

A. Attend commissioning team meetings held on a variable basis throughout the project’s construction phase.

B. Complete the pre-functional construction checklists after work is completed.

C. Perform functional commissioning tests at the direction of the CxA.

D. Attend construction phase controls coordination meeting.

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E. Attend testing, adjusting, and balancing review and coordination meeting.

F. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

G. Provide information requested by the CxA for final commissioning documentation.

H. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

I. Address commissioning comments made the CxA on the Issues Log.

1.6 CxA'S RESPONSIBILITIES

A. Provide project-specific pre-functional and functional construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct the functional commissioning testing.

C. Verify testing, adjusting, and balancing (TAB) of all tested systems are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.7 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan and Systems Manual:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

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PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 FUNCTIONAL TESTING PREPARATION

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

H. The contractor shall provide a written document (to the CxA) identifying all of the changes and deviations from the sequence of operation, approved by the Engineer of Record and Owner, listed in the design documents at least one week prior to the commencement of functional testing.

3.2 TESTING AND BALANCING VERIFICATION

A. Provide copies of reports, sample forms, checklists, and certificates to the CxA for review.

B. Notify the CxA at least 14 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide TAB technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing contractor 14 days in advance of the date of field verification. Notice will not include data points to be verified and will be selected by the commissioning agent and owner.
2. The testing and balancing contractor shall use the same instruments (by model and serial number) that were used when original data were collected.

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3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

D. The TAB Contractor shall be on site and available for five (5) days as part of the system functional testing. The TAB Contractor shall participate in verification of the functional commissioning checklist as directed by the CxA.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform functional commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Controls Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

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3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Boiler Testing and Acceptance Procedures: Testing requirements are specified in HVAC boiler Sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 "Instrumentation and Control for HVAC" and "Sequence and Operations for HVAC Controls." Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in HVAC piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of [oil] [gas] [coal] [steam] [hot-water] [and] [solar] systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

F. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

G. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

H. The following systems will be commissioned as part of this project:
1. HVAC Systems
    a. DDC Controls System
    b. Refer to list of equipment under Test and Balance
2. Plumbing Controls for Cells
3. Emergency Power Switch Over

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SECTION 23 09 23 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes DDC system for monitoring and controlling of HVAC systems.

B. Scope: Furnish all labor, materials and equipment necessary for a complete and operating Building Management System (BMS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over a single BACnet open protocol bus.

1. The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara N4™ Framework.
2. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, BACnet, and Modbus. Non BACnet communication protocol for specific pieces of equipment must be approved on a case by case basis.
3. System architecture shall provide secure Web access using MS Internet Explorer from any computer on the owner's LAN.
4. All control devices furnished with this Section shall be programmable directly from the Niagara-N4™ Workbench upon completion of this project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.
5. Any control vendor that must provide additional BMS server software shall be unacceptable. Only systems that utilize the WEBs Niagara N4™ Framework shall satisfy the requirements of this section.
6. The BMS server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the existing campus Niagara-N4 framework server
7. A laptop computer including engineering/programming software to modify Operating System Server BMS programs and graphics shall be included
8. **OPEN NIC STATEMENTS - All NiagaraN4 software licenses shall have the following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". All open NIC statements shall follow Niagara Open NIC specifications**

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product include:
   a. Product description with complete technical data, performance curves, and product specification sheets. Clearly indicate and highlight applicable information.
   b. Installation, operation and maintenance instructions.

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2. Software Submittal:

    a. Listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
    b. Description and technical data of all software provided.
    c. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
    d. Description of system database, including data included in database, database capacity and limitations to expand database.
    e. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, and model number. Include written description of sequence of operation including schematic diagram.

3. Shop Drawings:

    a. Floor plan drawings indicating the following:

        1) Each desktop workstation, server, gateway, router, DDC controller, control panel, damper, and valve connecting to DDC controller.
        2) Placement of devices in rooms, ducts, and piping.
        3) Network communication cable and raceway routing.
        4) Routing of wiring, cabling, conduit, and tubing, coordinated with building services.

    b. Schematic drawings for each controlled HVAC system indicating the following:

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1) I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve.
2) I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
3) Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
4) Unique identification of each I/O point.
5) Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
6) Narrative sequence of operation.

c. DDC system network riser diagram indicating each device connected to network with unique identification for each. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.

d. DDC system electrical power riser diagram indicating each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed, control power supplies, transformers, power-line conditioners, transient voltage suppression, high filter noise units, DC power supplies, UPS units, products requiring power with requirements, power wiring type and size, and raceway type.

e. Color graphics indicating itemized list of color graphic displays, a true color copy of each display screen, and intended operator access between related hierarchical display screens.

4. System Description:

a. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
b. Description of testing plans and procedures.
c. Description of Owner training.

B. Informational Submittals:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135 (BACnet).
2. Product Test Reports: For each product that requires testing.

C. Closeout Submittals:

1. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.

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c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Programming 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.
g. Engineering, installation, and maintenance manuals that explain how to:
    1) Design and install new points, panels, and other hardware.
    2) Perform preventive maintenance and calibration.
    3) Debug problems.
    4) Repair or replace hardware.
h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs or USB drive.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.3 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies. Install updates only after receiving Owner's written authorization.
3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two years from date of Substantial Completion.

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PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Automated Logic (by Automated Logic branch)
2. Alerton Inc, (by Open Control Systems)
3. Distech Controls (by Jackson Systems)
4. Honeywell International Inc. (by Honeywell branch)
5. Johnson Controls, Inc. (by Conserv or Johnson Controls branch)
6. Precision Controls.
7. EMCOR
8. Siemens Building Technologies, Inc. (by Siemens branch)
9. Trane. (by Trane branch)

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

A. DDC system shall be Web compatible. Server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

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a. DDC system shall manage HVAC systems.
b. DDC system control shall operate HVAC systems to achieve optimum operating costs while maintaining specified performance.
c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
d. DDC system shall operate while unattended by an operator as well as through operator interaction.
e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency. Flame-spread index 25 or less. Smoke-developed index 50 or less.

C. DDC System Speed:

1. Response Time of Connected I/O:

a. Input point values connected to DDC system updated at least every five seconds for use by DDC controllers. Points used globally also complying with this requirement.
b. Output points connected to DDC system begin to respond to controller output commands within two seconds. Global commands also complying with this requirement.

2. Display of Connected I/O:

a. Point changes of value connected to DDC system updated and displayed at least every 10 seconds for use by operator.
b. Alarms of points connected to DDC system displayed within 45 seconds of activation or change of state.
c. Graphic display refresh updated within eight seconds.

D. Network Bandwidth: Design each network of DDC system to include at least **30** percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

E. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. Local Storage: Provide server with data storage indicated. Servers shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.
3. Cloud Storage: Provide application-based and web browser interfaces to configure, upload, download, and manage data, and service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms

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and be capable of functions described in "DDC Data Access" Paragraph.

F. DDC Data Access: When logged into the system, operator able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.

Systems used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

G. Expandability: DDC system size expandable to an ultimate capacity of at least two times total I/O points indicated. Additional DDC controllers, I/O and associated cond shall be all that is needed to achieve ultimate capacity. Initial network infrastructure designed and installed to support ultimate capacity. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

H. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:

   a. Thermal: Within 3 percent of reading.
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.

2. Flow:

   a. Air: Within 5 percent of design flow rate.
   b. Air (Terminal Units): Within 10 percent of design flow rate.
   c. Water: Within 5 percent of design flow rate.

3. Gas:

   a. Carbon Dioxide: Within 50 ppm.
   b. Carbon Monoxide: Within 5 percent of reading.
   c. Oxygen: Within 5 percent of reading.
   d. Refrigerant: Within 50 ppm.

4. Moisture (Relative Humidity):

   a. Air: Within 5 percent RH.
   b. Space: Within 2 percent RH.
   c. Outdoor: Within 2 percent RH.

5. Level: Within 5 percent of reading.
6. Pressure:

   a. Air, Ducts and Equipment: 1 percent of instrument range.
   b. Space: Within 1 percent of instrument range.
   c. Water: Within 1 number> percent of instrument range.

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7. Speed: Within 5 percent of reading.
8. Temperature, Dew Point:

    a. Air: Within 1 deg F (0.5 deg C).
    b. Space: Within 1 deg F (0.5 deg C).
    c. Outdoor: Within 3 deg F (1.5 deg C).

9. Temperature, Dry Bulb:

    a. Air: Within 1 deg F (0.5 deg C).
    b. Space: Within 1 deg F (0.5 deg C).
    c. Outdoor: Within 1 deg F (0.5 deg C).
    d. Chilled Water: Within 1 deg F (0.5 deg C).
    e. Heating Hot Water: Within 1 deg F (0.5 deg C.
    f. Temperature Difference: Within 0.25 deg F (0.15 deg C).
    g. Other Temperatures Not Indicated: Within 1 deg F (0.5 deg C).

10. Temperature, Wet Bulb:

    a. Air: Within 1 deg F (0.5 deg C).
    b. Space: Within 1 deg F (0.5 deg C).
    c. Outdoor: Within 1 deg F (0.5 deg C).

11. Vibration: Within 5 percent of reading.

I. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:

    a. Milliamperes: Nearest 1/100th of a milliampere.
    b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

    a. Electric Power:

        1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
        2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
        3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

    b. Thermal, Rate:

        1) Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between

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1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh.

2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.

c. Thermal, Usage:

1) Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu.

2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.

3. Flow:

a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.

b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.

4. Gas:

a. Carbon Dioxide (ppm): Nearest ppm.
b. Carbon Monoxide (ppm): Nearest ppm.
c. Oxygen (Percentage): Nearest 1/10th of 1 percent.
d. Refrigerant (ppm): Nearest ppm.

5. Moisture (Relative Humidity):

a. Relative Humidity (Percentage): Nearest 1 percent.

6. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.

7. Speed:

a. Rotation (rpm): Nearest 1 rpm.
b. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.

8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.

9. Pressure:

a. Air, Ducts and Equipment: Nearest 1/10th in. w.c.
b. Space: Nearest 1/100th in. w.c.
c. Steam: Nearest 1/10th psig through 100 psig; nearest psig above 100 psig.
d. Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig.

10. Temperature:

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a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
b. Outdoor: Nearest degree.
c. Space: Nearest 1/10th of a degree.
d. Chilled Water: Nearest 1/10th of a degree.
e. Heating Hot Water: Nearest degree.

11. Vibration: Nearest 1/10th in/s.
12. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

J. Control Stability: Control variables indicated within the following limits:

1. Flow:

a. Air, Ducts and Equipment, except Terminal Units: Within 5 percent of design flow rate.
b. Air, Terminal Units: Within 10 percent of design flow rate.
c. Water: Within 5 percent of design flow rate.

2. Gas:

a. Carbon Dioxide: Within 50 ppm.
b. Carbon Monoxide: Within 5 percent of reading.
c. Oxygen: Within 5 percent of reading.
d. Refrigerant: Within 50 ppm.

3. Moisture (Relative Humidity):

a. Air: Within 5 percent RH.
b. Space: Within 2 percent RH.
c. Outdoor: Within 2 percent RH.

4. Level: Within 5 percent of reading.
5. Pressure:

a. Air, Ducts and Equipment: 1 percent of instrument range.
b. Space: Within 1 percent of instrument range.
c. Water: Within 1 percent of instrument range.

6. Temperature, Dew Point:

a. Air: Within 1 deg F. (0.5 deg C)
b. Space: Within 1 deg F. (0.5 deg C).

7. Temperature, Dry Bulb:

a. Air: Within 2 deg F (1 deg C).
b. Space: Within 2 deg F (1 deg C).
c. Chilled Water: Within 1 deg F (1 deg C).
d. Heating Hot Water: Within 2 deg F (1 deg C).

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8. Temperature, Wet Bulb:

    a. Air: Within 1 deg F (1 deg C).
    b. Space: Within 1 deg F (1 deg C).

K. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

    a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 3.
    b. Outdoors, Unprotected: Type 4.
    c. Indoors, Heated with Filtered Ventilation: Type 2.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
    e. Indoors, Heated and Air Conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: Type 4.
        2) Air-Moving Equipment Rooms: Type 1.

    g. Localized Areas Exposed to Washdown: Type 4.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
    i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
    j. Hazardous Locations: Explosion-proof rating for condition.

L. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the

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following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 3.
b. Outdoors, Unprotected: Type 4.
c. Indoors, Heated with Filtered Ventilation: Type 2.
d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
e. Indoors, Heated and Air-conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 4.
2) Air-Moving Equipment Rooms: Type 1.

g. Localized Areas Exposed to Washdown: Type 4.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
j. Hazardous Locations: Explosion-proof rating for condition.

M. DDC System Reliability:

1. Design, install and configure DDC controllers, gateways and routers to yield a mean time between failures of at least 40,000 hours, based on a confidence level of at least 90 percent. mean time between failures value shall include any failure for any reason to any part of products indicated.
2. If required to comply with mean time between failures indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control.
3. Critical systems and equipment that require a higher degree of DDC system redundancy than mean time between failures indicated shall be indicated on Drawings.

N. Electric Power Quality:

1. Power-Line Surges:

a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
b. Do not use fuses for surge protection.
c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

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a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

O. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

P. UPS:

1. DDC system products powered by UPS units shall include the following:

a. Desktop workstations.
b. Printers.
c. Servers.
d. Gateways.
e. DDC controllers, except application-specific controllers.

2. DDC system instruments and actuators powered by UPS units shall include the following:

a. Instruments associated with the following systems controlled by DDC system:

1) Pod exhaust, AHU controllers, RTU controllers, smoke dampers, fans, and all associated systems and components.

b. Dampers and actuators associated with the following systems controlled by DDC system:

1) Pod exhaust, AHU controllers, RTU controllers, smoke dampers, fans, and all associated systems and components.

c. Valves and actuators associated with the following systems controlled by DDC system:

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1) Pod exhaust, AHU controllers, RTU controllers, smoke dampers, smoke fans, and all associated systems and components.

Q. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 SYSTEM ARCHITECTURE

A. DDC system shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

B. System architecture shall be modular and have inherent ability to expand to not less than **two** times system size indicated with no impact to performance indicated.

C. System architecture shall perform modifications without having to remove and replace existing network equipment.

D. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

E. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

F. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2. Pod Exhaust System: For control application of air handling systems and integration with fire alarm and master override at control room.

2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.

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2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
5. Remote connection through web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room (at each Air Handling Unit in POD).
2. Inside of vehicle Sallyport.
3. Each boiler room.
4. Each chiller room or outdoor chiller yard.
5. Each different roof level with roof-mounted air-handling units or rooftop units.
6. Security system command center/Control Room.
7. Fire-alarm system command center.

D. Desktop Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system Level two LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
5. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
6. Have dynamic graphic displays that are identical to desktop workstations.

F. Portable Operator Terminal:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected o**r** connected to DDC system.

G. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each

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alarm.

3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

H. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.7 NETWORKS

A. Acceptable networks for connecting workstations and network controllers include the following:
1. IP.
2. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:
1. IP.
2. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:
1. EIA-485A.
2. IP.
3. IEEE 8802-3, Ethernet.

2.8 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

2.9 DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semi-permanent location.

B. Performance Requirements (Minimum):

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1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.

C. Personal Computer:

1. Minimum Processor Speed: Intel, 2.8 GHz.
2. RAM:

    a. Capacity: 4.0 GB.
    b. Speed and Type: 1333 MHz.

3. Hard Drive:

    a. Media: Solid state.
    b. Number of Hard Drives: One.
    c. Capacity: 1000 GB.

4. At least four expansion slots of 64 bit.
5. Video Card:

    a. Resolution: 1600 by 1200 pixels.
    b. Video Adapter
    c. 64 MB video memory
    d. TV out.

6. Network Interface Card: Include card with connection, as applicable.

    a. Integrated Intel Pro 10-100-1000 base Ethernet with RJ45 connector port.

D. Wireless Ethernet, 802.11 a/b/g/n.
1. I/O Ports:

    a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
    b. One serial port.
    c. One parallel port.
    d. Two PS/2 ports.
    e. One RJ45.
    f. One stereo line-in and headphone/line-out on back panel.
    g. One microphone and headphone connector on front panel.
    h. One IEEE 1394 on front and back panel with PCI-e card.
    i. One ESATA port on back panel.

2. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. DVD/RW:
1. 48x24x48

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F. Keyboard:

1. QWERTY, 105 keys.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.

G. Pointing Device:

1. Three-button, optical mouse.
2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

H. Flat Panel Display Monitor:

1. Display:

a. Color display with 19 inches diagonal viewable area, LCD color.
b. Digital input signal.
c. Aspect Ratio: 16 to 9.
d. Antiglare display.
e. Dynamic Contrast Ratio: 50000 to 1.
f. Brightness: 250 cd/sq. m.
g. Tilt adjustable base.
h. Energy Star compliant.
i. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
j. Number of Displays: One.

I. Speakers:

1. Two, with individual controls for volume, bass and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

J. I/O Cabling: Include applicable cabling to connect I/O devices.

2.10 PORTABLE WORKSTATIONS

A. Description: A self-contained computer designed to allow for normal use in different locations and conditions.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.
3. Hardware and software shall support local down-loading to DDC controllers.
4. Data transfer rate to DDC controller shall be at network speed.
5. Windows 10 Operating System to match Workstation with minimum 2 year license.

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C. Processor:
   1. RAM:
      a. Capacity: 2GB.
      b. Speed and Type: 1600 MHz, DDR3.
   2. Hard Drive:
      a. Number of Hard Drives: One.
      b. Capacity: 500 GB

D. Input and Output Ports:
   1. Serial port.
   2. Shared port for external keyboard or mouse.
   3. Four USB 3.0 ports.
   4. Ethernet port.
   5. HDMI port.
   6. IEEE 1394 port.

E. Battery:
   1. Capable of supporting operation of portable workstation for a minimum of 8 hours.
   2. Battery life of at least three years.
   3. Battery charge time of less than three hours.

F. Keyboard:
   1. 85-key backlit keyboard.
   2. Full upper- and lowercase ASCII keyset.

G. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.

H. Display:
   1. 11 inches diagonal or larger high-definition LED color display.
   2. Antiglare screen.
   3. 1920 by 1080 pixel resolution.
   4. Brightness: 300 nits.

I. Network Interfaces:
   1. Network Interface Card: Include card with connection, as application.
      a. Pro 10-100-1000 base Ethernet with RJ45 connector port.
   2. Wireless:
      a. Internal with integrated antenna, capable of supporting 802.11 a/b/g/n.

J. Digital Video Disc Rewrite Recorder (DVD+/-RW):

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1. Compatible with DVD disks and data, audio, recordable and rewritable compact disks.

2. 160-ms access time.

K. Accessories:

1. Nylon carrying case.
2. Docking station.
3. Mobile broadband card.
4. Wireless optical mouse.
5. 2 TB portable hard drive.
6. Light-sensitive web cam and noise-cancelling digital array microphone.
7. Category 6a patch cable. Minimum cable length shall be 10 ft.
8. HDMI cable. Minimum cable length shall be 10 ft.

2.11 PRINTERS

A. Color Laser Printer:
1. 1200 by 1200 dots per inch resolution black and white, 1200 by 1200 dots per inch resolution black and white and color.
2. First sheet printed within 10 seconds.
3. 4 pages per minute rated print speed at best quality mode.
4. Print buffer with at least 512 MB of RAM, expandable to at least one GB.
5. Complies with Energy Star requirements.
6. Capable of handling letter- and legal-size paper and overhead transparencies.
7. Two paper trays; one tray with 100 sheet capacity, and one tray with 500 sheet capacity.
8. At least 2-page toner/cartridge capacity.

2.12 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and

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exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:

    a. Operator access to DDC system shall be under password control.
    b. An alphanumeric password shall be field assignable to each operator.
    c. Operators shall be able to access DDC system by entry of proper password.
    d. Operator password shall be same regardless of which computer or other interface means is used.
    e. Additions or changes made to passwords shall be updated automatically.
    f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
    g. Software shall have at least five access levels.
    h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
    i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Data Segregation:

    a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
    b. Include at least 32 segregation groups.
    c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
    d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
    e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
    f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.

8. Operators shall be able to perform commands including, but not limited to, the following:

    a. Start or stop selected equipment.
    b. Adjust set points.

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c. Add, modify, and delete time programming.
d. Enable and disable process execution.
e. Lock and unlock alarm reporting for each point.
f. Enable and disable totalization for each point.
g. Enable and disable trending for each point.
h. Override control loop set points.
i. Enter temporary override schedules.
j. Define holiday schedules.
k. Change time and date.
l. Enter and modify analog alarm limits.
m. Enter and modify analog warning limits.
n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.

9. Reporting:

a. Generated automatically and manually.
b. Sent to displays, printers and disk files.
c. Types of Reporting:

1) General listing of points.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.

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5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

    a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
    c. Keyboard equivalent shall be available for those operators with that preference.

20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

    a. On-line context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
        1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed

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word-processing program, which shall run concurrently with operating system software.

c. Available for Every Menu Item:

1) Index items for each system menu item.

22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

1) Define background screens.
2) Define connecting lines and curves.
3) Locate, orient and size descriptive text.
4) Define and display colors for all elements.
5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

a. Room layouts with room identification and name.
b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
c. Location and identification of each hardware point being controlled or monitored by DDC system.
d. AHU Zones
e. Pod Control Zones.

3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, operator workstations and other network devices.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.

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2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. As a minimum, include the following modification capability:

    a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
    b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
    c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.
    d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
    e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
    f. Point related change capability shall include the following:

        1) System and point enable and disable.
        2) Run-time enable and disable.
        3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
        4) Assignment of alarm and warning limits.

    g. Application program change capability shall include the following:

        1) Enable and disable of software programs.
        2) Programming changes.
        3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:

    a. Proportional control (P).
    b. Proportional plus integral (PI).
    c. Proportional plus integral plus derivative (PID).

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d. Adaptive and intelligent self-learning control.

1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:

a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.

a. Class 1:

1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.

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2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

b. Class 2:

1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
2) Acknowledgement may be through a multiple alarm acknowledgment.

c. Class 3:

1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation for historical reporting.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on workstation hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

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1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

    a. Alarm history.
    b. System messages.
    c. System events.
    d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. Utility Reports: Prepare Project-specific reports.

1. Electric Report:

    a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
    b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
    c. Include annual report showing the monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
    d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as lighting, receptacles and HVAC equipment showing daily electrical consumption and peak electrical demand.
    e. For each weekly, monthly and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.

2. Natural Gas Report:

    a. Include weekly report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
    b. Include monthly report showing the daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
    c. Include annual report showing the monthly natural gas consumption and peak natural gas demand with time and date stamp for each meter.
    d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
    e. For each weekly, monthly and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.

K. Weather Reports:

1. Include daily report showing the following:

    a. Daily minimum, maximum, and average outdoor dry-bulb temperature.

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b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Daily minimum, maximum, and average outdoor dew point temperature.
d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).
e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
f. Daily minimum, maximum, and average outdoor carbon dioxide level.
g. Daily minimum, maximum, and average relative humidity.
h. Daily minimum, maximum, and average barometric pressure.
i. Daily minimum, maximum, and average wind speed and direction.

2. Include weekly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Daily minimum, maximum, and average outdoor dew point temperature.
d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).
e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
f. Weekly minimum, maximum, and average outdoor carbon dioxide level.
g. Daily minimum, maximum, and average relative humidity.
h. Daily minimum, maximum, and average barometric pressure.
i. Daily minimum, maximum, and average wind speed and direction.

3. Include monthly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
c. Daily minimum, maximum, and average outdoor dew point temperature.
d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).
e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
f. Monthly minimum, maximum, and average outdoor carbon dioxide level.
g. Daily minimum, maximum, and average relative humidity.
h. Daily minimum, maximum, and average barometric pressure.
i. Daily minimum, maximum, and average wind speed and direction.

4. Include annual (12-month) report showing the following:

a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
b. Monthly minimum, maximum, and average outdoor wet-bulb temperature.
c. Monthly minimum, maximum, and average outdoor dew point temperature.
d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).
e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
f. Annual minimum, maximum, and average outdoor carbon dioxide level.
g. Monthly minimum, maximum, and average relative humidity.

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h. Daily minimum, maximum, and average barometric pressure.
i. Daily minimum, maximum, and average wind speed and direction.

L. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

M. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

N. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be any of the following:

a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.13 OFFICE APPLICATION SOFTWARE

A. Include current version of office application software at time of Substantial Completion.

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B. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional" Windows 10 with high-speed Internet Access.

1. Database.
2. E-mail.
3. Presentation.
4. Publisher.
5. Spreadsheet.
6. Word processing.

2.14 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.15 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

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C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F (Zero to 50 deg C).
3. Controllers located outdoors shall be rated for operation at -10 to 150 deg F (40 to 65 deg C).

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches (900 mm) of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

    a. Network Controllers: 50 percent.
    b. Programmable Application Controllers: Not less than 60 percent.
    c. Application-Specific Controllers: Not less than 70 percent.

2. Memory shall support DDC controller's operating system and database and shall include the following:

    a. Monitoring and control.
    b. Energy management, operation and optimization applications.
    c. Alarm management.
    d. Historical trend data of all connected I/O points.
    e. Maintenance applications.
    f. Operator interfaces.
    g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

    a. 20 percent of each AI, AO, BI, and BO point connected to controller.
    b. Minimum Spare I/O Points per Controller:

        1) AIs: Three.

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2) AOs: Three.
3) BIs: Five.
4) BOs: Five.

2. Programmable Application Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Three.
2) AOs: Three.
3) BIs: Five.
4) BOs: Five.

3. Application-Specific Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: Two.
3) BIs: Three.
4) BOs: Three.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
d. Signal conditioning including transient rejection shall be provided for each AI.

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e. Capable of being individually calibrated for zero and span.
f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:

a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
b. Output signals shall have a range Division 26 for as required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:

a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
c. BOs shall be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
e. Limit use of three-point floating devices to VAV terminal unit control applications, and other applications indicated on Drawings. Control algorithms shall operate

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actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.16 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.
9. The SNC shall be a JACE 8000 supporting the Tridium N4 framework
10. JACE shall include a 3-year Software Maintenance Agreement (SMA)

B.

C. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

D. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.
2. Local Keypad and Display:

    a. Equip controller with local keypad and digital display for interrogating and editing data.
    b. Use of keypad and display shall require security password.

E. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss

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for at least 96 hours.

2.17 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage 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. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.
2. Local Keypad and Display:

    a. Equip controller with local keypad and digital display for interrogating and editing data.
    b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 96 hours.

2.18 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without

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being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.19 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.

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d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Schedules may be placed on scheduling calendar and will be repeated each year.
c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:

1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.

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2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Demand reduction shall be accomplished by the following means:

    a. Reset air-handling unit supply temperature set points.
    b. Reset space temperature set points.
    c. De-energize equipment based on priority.

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

    a. Addition and deletion of loads controlled.
    b. Changes in demand intervals.
    c. Changes in demand limit for meter(s).
    d. Maximum shutoff time for equipment.
    e. Minimum shutoff time for equipment.
    f. Select rotational or sequential shedding and restoring.
    g. Shed and restore priority.

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

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

J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:

1. Support any of the following control loops, as applicable to control required:

    a. Two-position (on/off, open/close, slow/fast) control.
    b. Proportional control.
    c. Proportional plus integral (PI) control.
    d. Proportional plus integral plus derivative (PID) control.

        1) Include PID algorithms with direct or reverse action and anti-windup.

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2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning).

M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

N. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

O. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

P. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.20 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Individual wall-mounted single-door enclosures shall not exceed 36 inches (900 mm) wide and 48 inches (1200 mm) high.
5. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
6. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements

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and standards indicated.

5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch- (6-mm-) high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
2. Construct enclosure of steel, not less than:

    a. Enclosure size less than 24 in. (600 mm): 0.053 in. (1.35 mm) or 0.067 in. (1.7 mm) thick.
    b. Enclosure size 24 in. (600 mm) and larger: 0.067 in. (1.7 mm) or 0.093 in. (2.36 mm) thick.

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3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

4. Hinged door full size of front face of enclosure and supported using:

    a. Enclosures sizes less than 36 in. (900 mm) tall: Multiple butt hinges.
    b. Enclosures sizes 36 in. (900 mm) tall and larger: Continuous piano hinges.

5. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size less than 24 in. (600 mm): Solid or Perforated steel, 0.053 in. (1.35 mm) thick.
    b. Size 24 in. (600 mm) and larger: Solid steel, 0.093 in. (2.36 mm) thick.

6. Internal panel mounting hardware, grounding hardware and sealing washers.
7. Grounding stud on enclosure body.
8. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide (1500 mm tall by 900 mm wide).
6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide (900 mm tall by 1500 mm wide).
7. Construct enclosure of steel, not less than the following:

    a. Size Less Than 24 Inches (600 mm): 0.053 inch (1.35 mm) or 0.067 inch (1.7 mm) thick.
    b. Size 24 Inches (600 mm) and Larger: 0.067 inch (1.7 mm) thick.

8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 Inches (600 mm) Tall: Two hinges.

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b. Sizes between 24 Inches (600 mm) through 48 Inches (1200 mm) Tall: Three hinges.
c. Sizes Larger 48 Inches (1200 mm) Tall: Four hinges.

10. Double-door enclosures with overlapping door design to include unobstructed full-width access.

    a. Single-door enclosures 48 inches (1200 mm) and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size Less Than 24 Inches (600 mm): Solid or perforated steel, 0.053 inch (1.35 mm) thick.
    b. Size 24 Inches (600 mm) and Larger: Solid steel, 0.093 inch (2.36 mm) thick.

12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
13. Grounding stud on enclosure body.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X SS:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
4. Construct enclosure of Type 304 or Type 316L stainless steel, not less than the following:

    a. Size Less Than 24 Inches (600 mm): 0.053 inch (1.35 mm) thick.
    b. Size 24 Inches (600 mm) and Larger: 0.067 inch (1.7 mm) thick.

5. Outside body and door of enclosure with brushed No. 4 finish.
6. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
7. Removable internal panel shall be 0.093-inch (2.36-mm) solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
8. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
9. Install corrosion-resistant polyester vent drain in a stainless-steel sleeve at the bottom of enclosure.
10. Include enclosure with stainless-steel mounting brackets.

G. Freestanding, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face.
4. Single-door enclosure sizes up to 84 inches tall by 36 inches wide (2100 mm tall by 900 mm wide).

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5. Construct enclosure of steel, not less than 0.067 inch (1.7 mm) thick.
6. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

7. Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.
8. Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.
9. Removable back covers.
10. Removable solid steel internal panel, 0.093 inch (2.36 mm) thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
12. Grounding stud on enclosure body.
13. Thermoplastic pocket on inside of door for record Drawings and Product Data.
14. Nominal 4-inch- (100-mm-) tall integral lifting base, not less than 0.123 inch (3.12 mm) thick, with predrilled holes for attachment to mounting surface.
15. Each top end of enclosure fitted with lifting tabs, not less than 0.172 inch (4.37 mm) thick.
16. Internal rack-mount shelves and angles as required by application.

H. Freestanding, NEMA 250, Types 4 and 12:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face.
4. Type 12 Enclosure Sizes:

    a. Single-door enclosure sizes up to 90 inches tall by 36 inches wide (2250 mm tall by 900 mm wide).

5. Type 4 Enclosure Sizes:

    a. Single-door enclosure sizes up to 72 inches tall by 36 inches wide (1800 mm tall by 900 mm wide).

6. Construct enclosure of steel, not less than 0.093 inch (2.36 mm) thick.
7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color shall be manufacturer's standard.
    b. Interior color shall be manufacturer's standard.

8. Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty oil-tight handle with integral locking mechanism.
10. Removable solid steel internal panel, 0.093 inch (2.36 mm) thick, with a white polyester

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powder coating that is electrostatically applied and then baked to bond to substrate.
Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
11. Grounding stud on enclosure body.
12. Thermoplastic pocket on inside of door for record Drawings and Product Data.
13. Top of enclosure fitted with no fewer than two lifting eyes.
14. Internal rack-mount shelves and angles as required by application.

I. Accessories:

1. Electric Heater:

a. Aluminum housing with brushed finish.
b. Thermostatic control with adjustable set point from zero to 100 deg F (Minus 18 to 38 deg C).
c. Capacity: 100, 200, 400, and 800 W as required by application.
d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

2. Ventilation Fans, Filtered Intake and Exhaust Grilles:

a. Number and size of fans, filters and grilles as required by application.
b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
d. Thermostatic control with adjustable set point from 32 to 140 deg F (Zero to 60 deg C).
e. Airflow Capacity at Zero Pressure:

1) 4-Inch (100-mm) Fan: 100 cfm (47 L/s).
2) 6-Inch (150-mm) Fan: 240 cfm (113 L/s).
3) 10-Inch (250-mm) Fan: 560 cfm (264 L/s).

f. Maximum operating temperature of 158 deg F (70 deg C).
g. 4-inch (100-mm) fan thermally protected and provided with permanently lubricated ball-bearings.
h. 6- and 10-inch (150- and 250-mm) fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
i. Dynamically balanced impellers molded from polycarbonate material.
j. Fan furnished with power cord and polarized plug for power connection.
k. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
l. Removable Intake and Exhaust Grilles: stainless steel of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
m. Filters for NEMA 250, Type 1 Enclosures: Washable aluminum, of a size to match intake grille.
n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

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3. Air Conditioner:
    a. Electric-powered, self-contained air-conditioning unit specially designed for electrical enclosures to maintain temperature inside enclosure below ambient temperature outside enclosure.
    b. Thermostatic control with adjustable set point from 60 to 120 deg F (16 to 49 deg C).
    c. Enclosure side or top mounting with unit capacity as required by application.
    d. Designed for closed-loop cooling with continuous operation in ambient environments up to 125 deg F (52 deg C).
    e. HFC refrigerant.
    f. Reusable and washable air filter.
    g. High-performance, industrial-grade, and high-efficiency fans.
    h. Furnished with power cord and polarized plug for power connection.
    i. Condensate management system with base pan side drain.
    j. Mounting hardware, gaskets, mounting template and instruction manual furnished with unit.
    k. Outdoor units equipped with head pressure control for low ambient operation, compressor heater, coated condenser coil and thermostat.

4. Thermoelectric Humidifier:
    a. ABS plastic enclosure.
    b. Capacity of 8 oz. (0.24 L) of water per 24 hours.
    c. Built-in drain captures moisture and plastic hose directs moisture to outside enclosure through a drain.
    d. Controlled to maintain enclosure relative humidity at an adjustable set point.
    e. Unit power supply shall be internally wired to enclosure electrical power source.

5. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:
    a. 0.25-inch- (6-mm-) thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
    b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
    c. Window kit shall be factory or shop installed before shipment to Project.

6. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:
    a. 0.125-inch- (3-mm-) thick, polycarbonate window mounted in enclosure door material.
    b. Window attached to door with screw fasteners and continuous strip of high-strength double-sided tape around window perimeter.
    c. Window kit shall be factory or shop installed before shipment to Project.

7. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:
    a. 0.25-inch- (6-mm-) thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
    b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.

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c. Window kit shall be factory or shop installed before shipment to Project.

8. Bar handle with keyed cylinder lock set.

2.21 RELAYS

A. General-Purpose Relays:

1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Relays shall have LED indication and a manual reset and push-to-test button.
7. Performance:

   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Pickup Time: 15 ms or less.
   d. Dropout Time: 10 ms or less.
   e. Pull-in Voltage: 85 percent of rated voltage.
   f. Dropout Voltage: 50 percent of nominal rated voltage.
   g. Power Consumption: 2 VA.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a dust-tight cover.
6. Include knob and dial scale for setting delay time.
7. Performance:

   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
   d. Repeatability: Within 2 percent.
   e. Recycle Time: 45 ms.
   f. Minimum Pulse Width Control: 50 ms.

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g. Power Consumption: 5 VA or less at 120-V ac.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:

a. Mechanical Life: At least 10 million cycles.
b. Electrical Life: At least 100,000 cycles at rated load.
c. Pickup Time: 15 ms or less.
d. Dropout Time: 10 ms or less.
e. Pull-in Voltage: 85 percent of rated voltage.
f. Dropout Voltage: 50 percent of nominal rated voltage.
g. Power Consumption: 2 VA.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).

7. Equip relays with coil transient suppression to limit transients to non-damaging levels.
8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:

1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:

1. Description:

a. On-off control and status indication in a single device.
b. LED status indication of activated relay and current trigger.

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c. Closed-Open-Auto override switch located on the load side of the relay.

2. Performance:
   a. Ambient Temperature: Minus 30 to 140 deg F (Minus 34 to 60 deg C).
   b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

3. Status Indication:

   a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
   b. Current Sensor Range: As required by application.
   c. Current Set Point: Fixed or adjustable as required by application.
   d. Current Sensor Output:

      1) Analog, zero- to 5- or 10-V dc.
      2) Analog, 4 to 20 mA, loop powered.

4. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
5. Enclosure: NEMA 250, Type 1 enclosure.

2.22 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least 100 VA.
3. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:

1. General Power-Line Conditioner Requirements:

   a. Design to ensure maximum reliability, serviceability and performance.
   b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

2. Standards: NRTL listed per UL 1012.
3. Performance:

   a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
   b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line

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voltage regulation when operating under less than full load conditions.

1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
h. Attenuate load-generated odd current harmonics 23 dB at the input.
i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
k. Common-mode noise attenuation of 140 dB.
l. Transverse-mode noise attenuation of 120 dB.
m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
n. Reliability of 200,000 hours' mean time between failures.
o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
p. Approximately 92 percent efficient at full load.

4. Transformer Construction:

a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
f. Electrically isolate the transformer secondary windings from the primary windings.

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Bond neutral conductor to cabinet enclosure and output neutral terminal.

g. Include interface terminals for output power hot, neutral and ground conductors.
h. Label leads, wires and terminals to correspond with circuit wiring diagram.
i. Vacuum impregnate transformer with epoxy resin.

5. Cabinet Construction:

a. Design for panel or floor mounting.
b. NEMA 250, Type 1, general-purpose, indoor enclosure.
c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
d. Include a textured baked-on paint finish.

C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:

1. The maximum continuous operating voltage shall be at least 125 percent.
2. The operating frequency range shall be 47 to 63 Hz.
3. Protection modes according to NEMA LS-1.
4. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:

a. Line to Neutral: 45,000 A.
b. Neutral to Ground: 45,000 A.
c. Line to Ground: 45,000 A.
d. Per Phase: 90,000 A.

5. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:

a. Line to Neutral: 360 V.
b. Line to Ground: 360 V.
c. Neutral to Ground: 360 V.

6. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.

a. Line to Neutral:

1) 100 kHz: 42 dB.
2) 1 MHz: 25 dB.
3) 10 MHz: 21 dB.
4) 100 MHz: 36 dB.

b. Line to Ground:

1) 100 kHz: 16 dB.
2) 1 MHz: 55 dB.
3) 10 MHz: 81 dB.
4) 100 MHz: 80 dB.

7. Unit shall have LED status indicator that extinguishes to indicate a failure.
8. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and

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as an electromagnetic interference filter per UL 1283.
9. Unit shall not generate any appreciable magnetic field.
10. Unit shall not generate an audible noise.

D. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:

a. Output voltage nominally 25-V dc within 5 percent.
b. Output current up to 100 mA.
c. Input voltage nominally 120-V ac, 60 Hz.
d. Load regulation within 0.5 percent from zero- to 100-mA load.
e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.23 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS FOR WORKSTATIONS

A. 250 through 1000 VA:

1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

a. Larger-capacity units shall be provided for systems with larger connected loads.
b. UPS shall provide five minutes of battery power.

3. Performance:

a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
d. On Battery Output Voltage: Sine wave.
e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
g. Transfer Time: 6 ms.
h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

4. UPS shall be automatic during fault or overload conditions.
5. Unit with integral line-interactive, power condition topology to eliminate all power

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contaminants.

6. Include front panel with power switch and visual indication of power, battery, fault and temperature.
7. Unit shall include an audible alarm of faults and front panel silence feature.
8. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
9. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.
10. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
11. Include tower models installed in ventilated cabinets to the particular installation location.

B. 1000 through 3000 VA:

1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

    a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.
    b. UPS shall provide 10 minutes of battery power.
    c. 2 kVa (Minimum)

3. Performance:

    a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.
    b. Power Factor: Minimum 0.97 at full load.
    c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.
    d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
    e. Recharge time shall be a maximum of eight hours to 90 percent capacity.

4. UPS bypass shall be automatic during fault or overload conditions.
5. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.
6. Batteries shall be sealed lead-acid type and be maintenance free.

Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration

2.24 PIPING AND TUBING

A. Pneumatic, and Pressure Instrument Signal Air, Tubing and Piping:

1. Products in this paragraph are intended for use with the following:

    a. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers and accessories.

2. Copper Tubing:

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a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B 75.
b. Performance, dimensions, weight and tolerance according to ASTM B 280.
c. Diameter, as required by application, not less than nominal 0.25 inch (6 mm).
d. Wall thickness, as required by the application, but not less than 0.030 inch (0.8 mm).

3. Copper Tubing Connectors and Fittings:

a. Brass, compression type.

b. Brass, solder-joint type.

4. Polyethylene Tubing:

a. Fire-resistant black virgin polyethylene according to ASTM D 1248, Type 1, Class C and Grade 5.
b. Tubing shall comply with stress crack test according to ASTM D 1693.
c. Diameter, as required by application, of not less than nominal 0.25 inch (6 mm).

5. Polyethylene Tubing Connectors and Fittings:

a. Brass, barbered fittings.

b. Brass, compression type.

B. Process Tubing:

1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.
2. Copper Tubing:

a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B 75.
b. Performance, dimensions, weight and tolerance according to ASTM B 280.
c. Diameter, as required by application, of not less than nominal 0.25 inch (6 mm).
d. Wall thickness, as required by application, but not less than 0.030 inch (0.8 mm).

3. Copper Tubing Connectors and Fittings:

a. Brass, compression type.

b. Brass, solder-joint type.

4. Stainless-Steel Tubing:

a. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.
b. Chemical and physical properties according to ASTM A 269.
c. Diameter, as required by application, of not less than nominal 0.25 inch (6 mm).
d. Wall thickness, as required by application, but not less than 0.035 inch (0.9 mm).

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e. Furnish stainless-steel tubing in 20-foot (6-mm) straight random lengths.

5. Stainless-Steel Tubing Connectors and Fittings:

a. Connectors and fittings shall be stainless steel, with stainless-steel collets, flareless type.

b. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.

2.25 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be as specified under Division 26. Wiring shall be furnished as part of Division 23 contractor's scope of work.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be as specified under Division 26. Wiring shall be furnished as part of Division 23 contractor's scope of work.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be as specified under Division 26. Wiring shall be furnished as part of Division 23 contractor's scope of work.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor

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colors shall be black, red and white.

7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable described in Division 26.

a. Cable shall be plenum rated.
b. Cable shall have a unique color that is different from other cables used on Project.

2.26 RACEWAYS

A. Comply with requirements in Division 26 for electrical power raceways and boxes.

B. Comply with requirements in Division 26 for raceways for balanced twisted pair cables and optical fiber cables.

2.27 OPTICAL FIBER CABLE AND CONNECTORS

A. Comply with requirements in Division 26 for optical fiber backbone cabling and connectors.

B. Comply with requirements in Division 26 for optical fiber horizontal cabling and connectors.

2.28 ACCESSORIES

A. Pneumatic Pressure Gages:

1. Pressure gages shall a 1.5-inch- (38-mm-) diameter face for pressures up through 30 psig (207 kPa) and 2.5-inch- (65-mm-) diameter face for greater pressures.
2. Include separate gages for branch pressure and main pressure lines.
3. White dial face with black printing.
4. Include 1-psig (6.9-kPa) increment for scale ranges through 30 psig (207 kPa) and 2-psig (13.8-kPa) increment for larger ranges.
5. Accuracy: Within 1 percent of full-scale range.

B. Pressure Electric Switches:

1. Diaphragm-operated snap acting switch.
2. Set point adjustable from 3 to 20 psig (21 to 138 kPa).
3. Differential adjustable from 2 to 6 psig (14 to 41 kPa).
4. Rated for resistance loads at 120-V ac.
5. Body and switch housing shall be metal.

C. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.

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2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

D. I/P and E/P Transducers:

1. Commercial Grade:
   a. The transducer shall convert an AO signal to a stepped pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig (21- to 103-kPa) pneumatic signal for pneumatic actuation.
   b. Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.
   c. Transducer shall have auto/manual output switch, manual output control and an output pressure gage.
   d. Accuracy: Within 1.0 percent of the output span.
   e. Linearity: Within 0.5 percent of the output span.
   f. Output Capacity: Not less than 550 scim at 15 psig (103 kPa).
   g. Transducer shall have separate zero and span calibration adjustments.
   h. The transducer shall withstand up to 40 psig (276 kPa) of supply pressure without damage.
   i. For use on only modulating pneumatic outputs that are associated with terminal units, including fan-coil units, VAV units and unit heaters.

2. Industrial Grade:

   a. The transducer shall convert an AO signal to a proportional pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig (21- to 103-kPa) pneumatic signal for pneumatic actuation. A stepped pneumatic signal is unacceptable.
   b. Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.
   c. Suitable for operation in an ambient temperature range of minus 40 to 150 deg F (minus 40 to 66 deg C).
   d. Accuracy: Within 0.5 percent of the output span.
   e. Linearity: Within 0.5 percent of the output span.
   f. Output Capacity: Not less than 5 scfm.
   g. Transducer shall have zero and span calibration adjustments.
   h. The transducer shall withstand up to 50 psig (345 kPa) of supply pressure without damage.
   i. For use on all modulating pneumatic outputs, not requiring a commercial-grade transducer.

E. E/P Switch:

1. Construct the body of cast aluminum or brass; three pipe body (common, normally open, and normally closed).
2. Internal construction of steel, copper or brass.
3. Air Connections: Barb.
4. Rating of 30 psig (207 kPa) when installed in systems below 25 psig (172 kPa) and of

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150 psig (1034 kPa) when installed in systems above 25 psig (172 kPa).
5. Include coil transient suppression.

F. Instrument Enclosures:

1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than 12 inches (300 mm) shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

G. Manual Valves:

1. Needle Type:

a. PTFE packing.
b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
c. Aluminum T-bar handle.
d. Include tubing connections.

2. Ball Type:

a. Body: Bronze ASTM B 62 or ASTM B 61.
b. Ball: Type 316 stainless steel.
c. Stem: Type 316 stainless steel.
d. Seats: Reinforced PTFE.
e. Packing Ring: Reinforced PTFE.
f. Lever: Stainless steel with a vinyl grip.
g. 600 WOG.
h. Threaded end connections.

H. Wall-Mounted Portable Workstation Cabinet:

1. Surface-mounted wall cabinet for tilt-out operation of laptop computers and large-format mobile devices.
2. Cabinet shall have a load limit of 50 lb (23 kg).
3. Cabinet shall include the following:

a. Oil-filled dampers for controlled lowering of equipment to operational position.
b. 3RU EIA mounting rails.
c. Removable laptop shelf.

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d. Separate top compartment with mounting area, hinged rail and security lock.
e. Front ventilation slots.
f. Knockouts for conduit connections on top and bottom of cabinet.

4. Cabinet shall be constructed of steel and painted with a powder-coat epoxy.

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5. Inside center of backbox shall have provision to mount a field-furnished and -installed, single gang electrical outlet box.

2.29 IDENTIFICATION

A. Instrument Air Pipe and Tubing:

1. Engraved tag shall bear the following information:

   a. Service (Example): "Instrument Air."
   b. Pressure Range (Example): 0 to 30 psig (0 to 200 kPa).

2. Letter size shall be a minimum of 0.25 inch (6 mm) high.
3. Tag shall consist of white lettering on blue background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded blue with contrasting white center exposed by engraving through outer layer.
5. Include tag with a brass grommet, chain and S-hook.

B. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label bearing unique identification.

   a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size shall be as follows:

   a. Operator Workstations: Minimum of 0.5 inch (13 mm) high.
   b. Servers: Minimum of 0.5 inch (13 mm) high.
   c. Printers: Minimum of 0.5 inch (13 mm) high.
   d. DDC Controllers: Minimum of 0.5 inch (13 mm) high.
   e. Gateways: Minimum of 0.5 inch (13 mm) high.
   f. Repeaters: Minimum of 0.5 inch (13 mm) high.
   g. Enclosures: Minimum of 0.5 inch (13 mm) high.
   h. Electrical Power Devices: Minimum of 0.5 inch (13 mm) high.
   i. UPS units: Minimum of 0.5 inch (13 mm) high.Accessories: Minimum of 0.25 inch (6 mm) high.
   j. Instruments: Minimum of 0.25 inch (6 mm) high.
   k. Control Damper and Valve Actuators: Minimum of 0.25 inch (6 mm) high.

3. Legend shall consist of white lettering on black background.
4. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.
5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

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C. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches (38 mm) in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

D. Raceway and Boxes:

1. Comply with requirements for identification specified in Division 26
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

E. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch (6 mm) beyond white border.

2.30 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate the following according to industry standards for each product, and to verify DDC system reliability specified in performance requirements:

1. DDC controllers.
2. Gateways.
3. Routers.
4. Operator workstations.

B. Product(s) and material(s) will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

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PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having an open protocol communication interface for remote monitoring or control.
2. Equipment to Be Connected:

a. Domestic water booster pumps specified in Division 22.
b. Air-terminal units specified in Division 23.
c. Boilers specified in Division 23.
d. Heat wheels and heat exchangers specified in Division 23.
e. Air-handling units specified in Division 23.
f. Roof-top units specified in Division 23.
g. Chillers specified in Division 23.
h. Variable-frequency controllers specified in Division 23.
i. Diesel emergency engine generators specified in Division 26.
j. Fire Alarm.
k. Pod Exhaust System.
l. Gas Detection/Monitoring.
m. Refrigerant monitoring.

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

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A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control dampers, which are specified in Division 23.
2. Airflow sensors and switches, which are specified in Division 23.
3. Pressure sensors, which are specified in Division 23.

C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control valves, which are specified in Section 230923.11 "Control Valves."
2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."
3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Division 23. Liquid temperature sensors, switches, and transmitters are specified in Division 23.
4. Pipe-mounted thermowells. Liquid thermowells are specified in Division 23.

3.4 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer.

1. Programmable application controller.
2. Unit-mounted DDC control dampers and actuators, which are specified in Division 23.
3. Unit-mounted airflow sensors, switches and transmitters, which are specified in Division 23.
4. Unit-mounted gas sensors and transmitters, which are specified in Division 23.
5. Relays.

B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.

1. Application-specific controller.
2. Unit-mounted flow and pressure sensors, transmitters and transducers. Flow sensors, transmitters, and transducers are specified in Division 23. Pressure sensors, switches, and transmitters are specified in Division 23.
3. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Division 23.
4. Relays.

3.5 GENERAL INSTALLATION REQUIREMENTS

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A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Division 7.

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Division 7.

H. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

J. Corrosive Environments:

1. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive- resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Division 26.
2. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.6 WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on workstation(s) and verify software functions properly.

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4. Develop Project-specific graphics, trends, reports, logs and historical database.

Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

D. Wall-Mounted Portable Operator's Workstation Cabinet Installation:

1. Install wall-mounted portable operator's workstation cabinet(s) at following location(s) and at locations directed by Owner:
   a. Boiler mechanical room.
   b. Mezzanine Control Room.

2. Connect each cabinet to 120-V, single-phase, 60Hz field power source, and install single gang electrical box with NEMA WD 6, Type 20R duplex receptacle and metal cover plate in cabinet. Comply with requirements in Division 26 "Wiring Devices."
3. Connect each cabinet to Ethernet network and install an Ethernet network port for connection to portable operator workstation Ethernet cable. Comply with requirements in Division 26 or 27 for Horizontal Cabling.

3.7 PORTABLE OPERATOR TERMINAL INSTALLATION

A. Install one portable operator terminal.

B. Turn over portable operator terminals to Owner at Substantial Completion.

C. Install software on each portable operator terminal and verify that software functions properly.

3.8 PRINTER INSTALLATION

A. Provide the following printer(s) at location(s) directed by Owner:
   1. Color Laser: Quantity, one.

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B. Install printer software on workstations and verify that software functions properly.

3.9 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.
   1. Install gateway(s) required to suit indicated requirements.

B. Test gateway to verify that communication interface functions properly.

3.10 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

   1. Install router(s) required to suit indicated requirements.

B. Test router to verify that communication interface functions properly.

3.11 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

   B. Connect controllers to field power supply. and to UPS units where indicated.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

   1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. Install controllers in a protected location that is easily accessible by operators.
   3. Top of controller shall be within 72 inches (1800 mm) of finished floor.

F. Installation of Programmable Application Controllers:

   1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. Install controllers in a protected location that is easily accessible by operators.
   3. Top of controller shall be within 72 inches (1800 mm) of finished floor.

G. Application-Specific Controllers:

   1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. For controllers not mounted directly on equipment being controlled, install

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controllers in a protected location that is easily accessible by operators.

3.12 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.Relays.
6. Accessories.
7. Instruments.
8. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use corrosion-resistant-coated steel strut and hardware.
2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top of adjacent enclosures.

D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using stainless-steel anchors.

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.13 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Division 26 for electrical power circuit breakers.

D. Comply with requirements in Division 26 for electrical power conductors and cables.

E. Comply with requirements in Division 26 for electrical power raceways and boxes.

3.14 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with

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requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install self-adhesive labels with unique identification on face for each of the following:

1. Operator workstation.
2. Server.
3. Printer.
4. Gateway.
5. Router.
6. DDC controller.
7. Enclosure.
8. Electrical power device.
9. UPS unit.
10. Accessory.

C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification on face of each control damper and valve actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be in highly visible location near power service entry points.

3.15 NETWORK INSTALLATION

A. Install optical fiber cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds 100 meters:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

B. Install balanced twisted pair or optical fiber cable when connecting between the following network devices located in same building:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

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C. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

1. Gateways.
2. Gateways and network controllers or programmable application controllers.
3. Routers.
4. Routers and network controllers or programmable application controllers.
5. Network controllers and programmable application controllers.
6. Programmable application controllers.
7. Programmable application controllers and application-specific controllers.
8. Application-specific controllers.

D. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.16 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

a. Every network device shall have an assigned and documented MAC address unique to its network.
b. Ethernet Networks: Document MAC address assigned at its creation.
c. ARCNET or MS/TP networks: Assign from 00 to 64.

2. Network Numbering:

a. Assign unique numbers to each new network.
b. Provide ability for changing network number through device switches or operator interface.
c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

a. Assign unique device object identifier property numbers or device instances for each device network.
b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN shall support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

a. Device object name property field shall support 32 minimum printable

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characters.

b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."

2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field shall support 32 minimum printable characters.
b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."
2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to Drawings or tables indicated.
b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.17 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:
1. Provide rigid conduit in any exposed area 11 ft and below. Above 11 ft, free air cabling is acceptable in areas not accessible to inmates.
2. Controls Contractor shall procure all wiring and cabling for controls system.
3. Comply with installation requirements in Division 26 for Electrical Power Cables.
4. Comply with installation requirements in Division 27 for communications copper backbone cabling.
5. Comply with installation requirements in Division 27 for communications copper horizontal cabling.
6. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

7. Terminate wiring in a junction box.

a. Clamp cable over jacket in junction box.
b. Individual conductors in the stripped section of the cable shall be slack

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between the clamping point and terminal block.

8. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
9. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
10. Use shielded cable to transmitters.
11. Use shielded cable to temperature sensors.
12. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Division 26 for control-voltage conductors.
2. Comply with Division 27 for balanced twisted pair cabling and optical fiber installation.

3.18 OPTICAL FIBER CABLE SYSTEM INSTALLATION

A. Comply with installation requirements in Division 27 for Optical Fiber Backbone Cabling.

B. Comply with installation requirements in Division 27 for Optical Fiber Horizontal Cabling.

3.19 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 installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.

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4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.20 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. Verify that control valves are installed correctly for flow direction.
2. Verify that valve body attachment is properly secured and sealed.
3. Verify that valve actuator and linkage attachment is secure.
4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
5. Verify that valve ball, disc or plug travel is unobstructed.
6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.

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4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

    a. Verify sensing element type and proper material.
    b. Verify length and insertion.

3.21 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

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K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.22 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.

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5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.23 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.24 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

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1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Each controller's programming is backed up.
10. Equipment, products, tubing, wiring cable and conduits are properly labeled.
11. All I/O points are programmed into controllers.
12. Testing, adjusting and balancing work affecting controls is complete.
13. Dampers and actuators zero and span adjustments are set properly.
14. Each control damper and actuator goes to failed position on loss of power.
15. Valves and actuators zero and span adjustments are set properly.
16. Each control valve and actuator goes to failed position on loss of power.
17. Meter, sensor and transmitter readings are accurate and calibrated.
18. Control loops are tuned for smooth and stable operation.
19. View trend data where applicable.
20. Each controller works properly in standalone mode.
21. Safety controls and devices function properly.
22. Interfaces with fire-alarm system function properly.
23. Electrical interlocks function properly.
24. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
25. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation minimum of 20 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.

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1) Identify I/O points for future reference.
2) Simulate abnormal conditions to demonstrate proper function of safety devices.
3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:

   a. Re-check I/O points that required corrections during initial test.
   b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:

   a. Re-check I/O points that required corrections during second test.
   b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate heavy load conditions.

   a. Heavy load shall be an occurrence of 50 percent of total connected binary changes of value, one-half of which represent an "alarm" condition, and 50 percent of total connected analog changes of value, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of heavy load conditions and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:

   a. Reaction to changes of value and alarm conditions during heavy load conditions.
   b. Ability to update DDC system database during heavy load conditions.

5. Passing test is contingent on the following:

   a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of heavy load conditions.
   b. All alarms, both binary and analog, are reported and printed; none are lost.
   c. Compliance with response times specified.

6. Prepare and submit a report documenting heavy load conditions tested and results of

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test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated heavy load conditions.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and heavy load conditions operation.

3.25 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:

a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may

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be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.

b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to **10** I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.

c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.

f. Trends, summaries, logs and reports set-up for Project.

g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

i. Software's ability to edit control programs off-line.

j. Data entry to show Project-specific customizing capability including parameter changes.

k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

l. Execution of digital and analog commands in graphic mode.

m. Spreadsheet and curve plot software and its integration with database.

n. Online user guide and help functions.

o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

p. System speed of response compared to requirements indicated.

q. For Each Network and Programmable Application Controller:

1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
4) Electric Power: Ability to disconnect any controller safely from its power source.
5) Wiring Labels: Match control drawings.
6) Network Communication: Ability to locate a controller's location on network and communication architecture matches

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Shop Drawings.

7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

r. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.
2) Graphics are complete.
3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:

a) Display of network device status.
b) Display of BACnet Object Information.
c) Silencing devices transmitting erroneous data.
d) Time synchronization.
e) Remote device re-initialization.
f) Backup and restore network device programming and

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master database(s).

g) Configuration management of routers.

3.26 ADJUSTING

A. Occupancy Adjustments: Contractor shall contact Owner within 10 months after substantial completion and provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose. Notify Engineer of Record to document each visit.

3.27 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 6 months' full maintenance by DDC system manufacturer's authorized service representative. Include monthly, quarterly, and semiannual preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.28 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for three years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.29 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

a. Provide not less than five days of training total.

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b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
c. Total days of training shall be broken into not more than three separate training classes.
d. Each training class shall be not less than two consecutive days.

C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least 20 business days of notice in advance of training.
3. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

E. Training Attendee Headcount:

1. Plan in advance of training for attendees.
2. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

G. Instructor Requirements:

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1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

H. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

   a. Daily operators.
   b. Advanced operators.
   c. System managers and administrators.

2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

I. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

J. On-Site Training:

1. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
2. Provide as much of training located on-site as deemed feasible and practical by Owner.
3. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
4. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

K. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.

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8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:

    a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
    b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
    c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
    d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
    e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
    f. Each control loop responds to set point adjustment and stabilizes within time period indicated.
    g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

26. Pod Exhaust System.

L. Training Content for Advanced Operators:

1. Making and changing workstation graphics.

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2. Creating, deleting and modifying alarms including annunciation and routing.
3. Creating, deleting and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting and modifying reports.
5. Creating, deleting and modifying points.
6. Creating, deleting and modifying programming including ability to edit control programs off-line.
7. Creating, deleting and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing and repairing hardware.
15. Adjusting, calibrating and replacing DDC system components.

M. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading and off-line archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

N. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 23 09 23

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SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fittings for hydronic piping.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of the following:

a. Pipe.
b. Fittings.
c. Joining materials.
d. Bypass chemical feeder.

2. Delegated-Design Submittal:

a. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
b. Locations of pipe anchors and alignment guides and expansion joints and loops.
c. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
d. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

B. Informational Submittals:

1. Qualification Data: For Installer.
2. Welding certificates.
3. Field quality-control reports.
4. Preconstruction Test Reports:

a. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.3 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

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

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.4 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on water quality.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 100 psig at 180 deg F.
2. Chilled-Water Piping: 150 psig at 73 deg F.
3. Condenser-Water Piping: 150 psig at 73 deg F.
4. Glycol Cooling-Water Piping: 150 psig at 150 deg F.
5. Makeup-Water Piping: 80 psig at 73 deg F.
6. Condensate-Drain Piping: 150 deg F.
7. Blowdown-Drain Piping: 180 deg F.
8. Air-Vent Piping: 180 deg F.
9. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

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a. Anvil International.
b. Victaulic.
c. or Engineered/Owner Approved Equal.

2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.
   a. Grooved-End Tube Couplings, 2" and up: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves. Gasket shall be Grade "EHP" EPDM compound designed for temperatures from -30 deg F to +250 deg F. Victaulic Style 607 or Engineered/owner approved equal

E. Copper or Bronze Pressure-Seal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

   a. NIBCO Inc.
   b. Viega, LLC.

2. Housing: Copper.
3. O-Rings and Pipe Stops: EPDM.
4. Tools: Manufacturer's special tools.
5. Minimum 200-psig working-pressure rating at 250 deg F.

F. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

   a. T-Drill Industries Inc.

G. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

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D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Anvil International.
    b. Victaulic.
    c. or Engineered/Owner Approved Equal.

2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
    a. Rigid Couplings: Victaulic Styles 107N/W07 or Owner/Engineered approved Equal. Gaskets shall be grade “EHP” EDPM designed for operating temperatures from -30 deg F to +250 deg F.
    b. Flexible Couplings: Use in locations where vibration attenuation and stress relief are required. Three flexible couplings may be used in lieu of flexible connectors at equipment connections and shall be placed in close proximity to the vibration source. Victaulic Style 177, W77 or Owner/Engineered approved equal.
    c. Victaulic Installation-Ready™ fittings for all schedules plain end carbon steel piping in HVAC and mechanical applications sizes ½” through 2”.

I. Steel Pressure-Seal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Apollo.

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b. Viega.
c. Victaulic Company.

2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig working-pressure rating at 230 deg F.

J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.

B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.

1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

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G. Solvent Cements for CPVC Piping: ASTM F 493. Solvent cement VOC content 490 g/L or less. Adhesive primer VOC content 550 g/L or less.

H. Solvent Cements for PVC Piping: ASTM D 2564. Primer ASTM F 656. Solvent cement VOC content 510 g/l or less. Adhesive primer VOC content 550 g/L or less.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Charlotte Pipe and Foundry Company.
    b. IPEX Inc.
    c. KBI (King Bros. Industries).

2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. NIBCO Inc.; Model T/S-1710.
    b. Charlotte Pipe and Foundry Company.
    c. IPEX Inc.
    d. KBI (King Bros. Industries).

2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. A.Y. McDonald Mfg. Co.
    b. Capitol Manufacturing Company.
    c. Central Plastics Company.
    d. Hart Industries International, Inc.

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e. Jomar International, Ltd.
f. Matco-Norca.
g. Watts Regulator Co.
h. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.
i. Victaulic 647

2. Description:

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

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Matco-Norca.
d. Watts Regulator Co.
e. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

2. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

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E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Elster-Perfection.
    b. Grinnell Mechanical Products.
    c. Matco-Norca.
    d. Precision Plumbing Products, Inc.
    e. Victaulic Company.

2. Description:

    a. Standard: IAPMO PS 66.
    b. Electroplated steel nipple, complying with ASTM F 1545.
    ~~c.~~ Pressure Rating: 300 psig at 225 deg F.
    d. End Connections: Male threaded or grooved.
    e. Lining: Inert and noncorrosive, propylene.

2.8 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gallon capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, soldered and brazed joints.
2. Schedule 40, Grade B steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; Victaulic Installation-Ready™ fittings and threaded joints.
3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger shall be any of the following:

1. Type L~~,~~ drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Hot-water heating piping installed belowground and within slabs shall be the following:

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1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

D. Chilled-water piping, aboveground, NPS 2 and smaller shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; Victaulic Installation-Ready™ fittings and threaded joints.
3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
4. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

E. Chilled-water piping, aboveground, NPS 2-1/2 and larger shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

F. Chilled-water piping installed belowground and within slabs shall be the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

G. Condenser-water piping, aboveground, NPS 2 and smaller shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 80 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; Victaulic Installation-Ready™ fittings and threaded joints.
3. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

H. Condenser-water piping, aboveground, NPS 2-1/2 and larger shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 80 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 80 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

I. Condenser-water piping installed belowground and within slabs shall be the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

J. Glycol cooling-water piping, aboveground, NPS 2 and smaller shall be any of the following:

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1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; Victaulic Installation-Ready™ fittings and threaded joints.
3. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

K. Glycol cooling-water piping, aboveground, NPS 2-1/2 and larger shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

L. Glycol cooling-water piping installed belowground and within slabs shall be the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

M. Makeup-water piping installed aboveground shall be either of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 80 CPVC plastic pipe and fittings, and solvent-welded joints.

N. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

O. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

P. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

Q. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

R. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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C. Install piping 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 equipment and valve servicing.

F. Install horizontal piping at a uniform grade of 0.2 percent upward in direction of flow. Install vertical piping plumb.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install air vents, consisting of a tee fitting, NPS 3/4 ball valve, short NPS 3/4 threaded nipple, reducer, and air vent, at high points in piping. Use automatic air vents in mechanical rooms and run copper tubing from vent discharges to floor drains. Use manual air vents in other locations unless indicated otherwise.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the top or side of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to the valve specifications.

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in other Division 23 Sections for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in other Division 23 Sections for identifying piping.

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V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in other Division 23 Sections.

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in other Division 23 Sections.

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in other Division 23 Sections.

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2-and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in other Division 23 Sections for hanger, support, seismic restraint, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for steel piping with the following maximum spacing:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.

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3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions and local codes. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.

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4. PVC Nonpressure Piping: Join according to ASTM D 2855.

I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

J. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

3.7 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor:

    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
    e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
9. Ammonia: Maximum of 20 ppm.
10. Free Caustic Alkalinity: Maximum of 20 ppm.
11. Microbiological Limits:

    a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
    c. Nitrate Reducers: 100 organisms/mL.
    d. Sulfate Reducers: Maximum of zero organisms/mL.

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e. Iron Bacteria: Maximum of zero organisms/mL.

B. Install bypass chemical feeders in each hydronic system where indicated. Install in upright position with top of funnel not more than 48 inches above the floor.

C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

E. Fill systems that have antifreeze or glycol solutions with concentrations indicated on the Drawings.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

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1. Open manual isolation valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

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SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hydronic piping specialties.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product:

    a. Include construction details and material descriptions for hydronic piping specialties.
    b. Include rated capacities, operating characteristics, and furnished specialties and accessories.
    c. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

B. Closeout Submittals:

1. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.
2. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.3 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Plastic Ball Valves:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Asahi/America.
    b. Georg Fischer Inc.
    c. Hayward Flow Control.
    d. Plast-O-Matic Valves, Inc.
    e. TVI (Thermoplastic Valves, Inc.)

2. Body: Three-piece CPVC or PVC to match piping.
3. Ball: Full-port CPVC or PVC to match piping.
4. Seats: PTFE.
5. Seals: EPDM.
6. End Connections: Socket, union, or flanged.
7. Handle Style: Tee shape.
8. CWP Rating: Equal to piping service.
9. Maximum Operating Temperature: Equal to piping service.
10. Comply with MSS SP-122.

B. Plastic Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Asahi/America.
    b. Georg Fischer Inc.
    c. Hayward Flow Control.
    d. Plast-O-Matic Valves, Inc.
    e. TVI (Thermoplastic Valves, Inc.)

2. Body: PVC or CPVC to match piping; wafer type for installation between flanges.
3. Disc: EPDM-coated steel.
4. Seats: PTFE.
5. Handle Style: Locking lever.
6. CWP Rating: Equal to piping service.
7. Maximum Operating Temperature: Equal to piping service.

C. Plastic Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Asahi/America.
    b. Georg Fischer Inc.
    c. Hayward Flow Control.
    d. Plast-O-Matic Valves, Inc.
    e. TVI (Thermoplastic Valves, Inc.)

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2. Body: PVC or CPVC to match piping; ball, piston, disc, or swing check type for horizontal or vertical installation.
3. Ball, Piston, or Disc: Match body material.
4. Seats and Seals: EPDM.
5. CWP Rating: Equal to piping service.
6. Maximum Operating Temperature: Equal to piping service.

D. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Armstrong Pumps, Inc.
    b. Griswold Controls.
    c. Hays Fluid Control.
    d. Taco Comfort Solutions.
    e. Xylem Bell & Gossett.
    f. Victaulic

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

E. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Armstrong Pumps, Inc.
    b. Griswold Controls.
    c. Hays Fluid Control.
    d. Taco Comfort Solutions.
    e. Xylem Bell & Gossett.
    f. Victaulic

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.

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10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

F. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Spence Engineering Company.
    d. Watts.
    e. Xylem Bell & Gossett.
    f. Victaulic

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Spence Engineering Company.
    d. Watts.
    e. Xylem Bell & Gossett.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

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H. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Flow Design, Inc.
    b. Griswold Controls.
    c. Hays Fluid Control.
    d. Nexus Valve, Inc.
    e. Victaulic

2. Body: Brass or ferrous metal.
3. Flow Control Assembly, provide either of the following:

    a. Piston and Spring Assembly: Corrosion resistant, tamper proof, self-cleaning, and removable.
    b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.

4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Spence Engineering Company.
    d. Taco Comfort Solutions.
    e. Xylem Bell & Gossett.

2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

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B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Spirotherm, Inc.
    d. Taco Comfort Solutions.
    e. Xylem Bell & Gossett.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Bladder-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Grundfos.
    d. Taco Comfort Solutions.
    e. Xylem Bell & Gossett.

2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed. Flanged connection for bladder replacement. Label according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Diaphragm-Type Non-ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Taco Comfort Solutions.
    d. Xylem Bell & Gossett.

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2. Tank: Carbon steel, rated for minimum 100-psig working pressure at minimum 200 deg F maximum operating temperature. Non-ASME construction.
3. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fitting: Schrader valve, stainless steel with EPDM seats.

E. Coalescing-Type Air and Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Armstrong Pumps, Inc.
    b. Grundfos.
    c. Spirotherm, Inc.
    d. Xylem Bell & Gossett.

2. Tank: Fabricated steel tank; ASME constructed and stamped for 125-psig working pressure and 270 deg F maximum operating temperature.
3. Coalescing Medium: [Copper] [Stainless steel].
4. Air Vent: Threaded to the top of the separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 and smaller; Class 150 flanged connections for NPS 2-1/2 and larger.
6. Blowdown Connection: Threaded to the bottom of the separator.
7. Size: Match system flow capacity.
8. Performance: Unit shall include internal structured elements filling the entire vessel to suppress turbulence and provide air elimination efficiency of 100% free air, 100% entrained air, and 99.6% dissolved air at the installed location. Dirt separation efficiency shall be a minimum of 80% of all particles 30 micron and larger within 100 passes. The elements must be fabricated by the manufacturer and consist of a copper core tube with continuous wound copper wire medium permanently attached and followed by a separate continuous wound copper wire permanently affixed.

F. Tangential-Type Air Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Grundfos.
    d. Taco Comfort Solutions.
    e. Xylem Bell & Gossett.

2. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into vent connection.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.

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5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

G. In-Line Air Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Grundfos.
    d. Taco Comfort Solutions.
    e. Xylem Bell & Gossett.

2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig.
4. Maximum Operating Temperature: Up to 300 deg F.

H. Air Purgers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Taco Comfort Solutions.
    d. Xylem Bell & Gossett.

2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger. Victaulic Series 732 Acceptable
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.

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2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellows, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

B. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

C. Three flexible couplings may be used in lieu of flexible connectors at equipment connections and shall be placed in close proximity to the vibration source. Victaulic Style 177, W77 or Owner/Engineered approved equal.

2.5 MODULAR EQUIPMENT CONNECTION ASSEMBLIES

A. All components listed below shall meet the requirements listed elsewhere in this specification.

B. Pump Trim: Suction
1. Series 381 Suction Vibration Isolation Pump Drop. Factory assembled grooved end vibration pump suction drop for pipe sizes 3” through 12”. Orange enamel coated assembly, consisting of a suction diffuser with stainless steel basket and diffuser and Class 150 flange for pump connection, butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and/or pressure ports. Assembly is installation-ready, with

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flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure to 300-psig. Standard of Acceptance: Victaulic Series 381.

C. Pump Trim: Discharge
1. Series 380 Discharge Vibration Pump Drop. Factory assembled grooved end vibration pump discharge drop for pipe sizes 3" through 12" Orange enamel coated assembly, consisting of a Class 150 flange for pump connection, [base elbow for horizontal pump connection] [straight line with concentric reducer for vertical pump connections], tri-service valve assembly consisting of a spring-actuated check valve and butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and pressure ports. Assembly is installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure to 300-psig Standard of Acceptance: Victaulic Series 380.

D. Header
1. Factory-fabricated grooved end header [manifold] all-in-one assembly for fluid distribution. Header shall consist of an ASTM A53, Grade B, standard weight pipe spool with required outlet connections. Grooved ends roll grooved to Victaulic [OGS] [AGS] dimensions, with enamel coating or galvanized to project requirements. Standard of Acceptance: Victaulic Vic-Header.

E. Air Handling Unit Trim
1. Series 385 Vibration Isolation Air Handling Unit Drop. Manufactured grooved end vibration isolation drop for air handling unit coil supply and return connections in sizes 2" through 6" (DN50 though DN150) to accommodate isolation, straining, balancing, and drainage. Orange enamel coated drop, consisting of ASTM A53 carbon steel pipe spool(s), Victaulic #20 (straight) and #25 (reducing) tees or Style 920/920N Mechanical-T fittings, with base end cap with drain outlet and DZR brass drain valve. Supply connections include a Vic-300 MasterSeal butterfly valve and Style 732 Y-pattern strainer with PT ports, and the return connection includes a Series 787 or 789 circuit balancing valve. Installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief, rated for working pressure to 300-psig (2068-kPa). Standard of Acceptance: Victaulic Series 385.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

B. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install specialties in accordance with manufacturer's instructions.

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B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install in-line air separators on suction side of pump. Install drain valve on air separators NPS 2 and larger.

D. Install tangential or coalescing air separator on suction side of pump. Install blowdown piping with isolation valve; extend full size to nearest floor drain.

E. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 23 21 16

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SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Close-coupled, end-suction centrifugal pumps.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
2. Shop Drawings: For each pump.

    a. Show pump layout and connections.
    b. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
    c. Include diagrams for power, signal, and control wiring.

B. Closeout Submittals:

1. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.
2. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

    a. Mechanical Seals: One set of mechanical seals for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Armstrong Pumps, Inc.
2. Bell & Gossett; Xylem Inc.
3. PACO Pumps: Grundfos Pumps Corporation USA.

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4. TACO Comfort Solutions, Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2; designed for installation with pump and motor shafts mounted horizontally or vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet and threaded companion-flange or union-end connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N, EPT, or Viton (as required by operating conditions) bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed and rigidly mounted to pump casing. Comply with requirements for motors in Section 23 05 13.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Armstrong Pumps, Inc.
2. Aurora Pumps; Pentair Ltd.
3. Bell & Gossett; Xylem Inc.
4. PACO Pumps: Grundfos Pumps Corporation USA.
5. Peerless Pump Company.
6. TACO Comfort Solutions, Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve; or stainless steel.

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4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N, EPT, or Viton (as required by operating conditions) bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings or oil lubricated; bronze-journal or thrust bearings.

D. Motor: Single speed and rigidly mounted to pump casing with integral pump support. Comply with requirements for motors in Section 23 05 13.

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig or 300-psig pressure rating (as required by conditions), cast-iron or ductile-iron body and end cap, pump-inlet fitting.
3. Bronze or stainless-steel startup and permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig or 300-psig pressure rating (as required by conditions), cast-iron or ductile-iron body, pump-discharge fitting. Threaded, flanged, or grooved connections.
3. Bronze-fitted globe valve with disc, EPDM seat, and stainless-steel stem and spring. Valve arranged for shutoff, manual balancing, and non-slam check valve functions.
4. Brass gage ports with integral check valve and orifice for flow measurement.
5. Drain plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4 for centrifugal pumps.

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B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Base-Mounted Pumps Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 3.
2. Comply with requirements for vibration isolation and seismic control devices specified in other Division 23 Sections.

E. In-Line Pumps Mounting: Install in-line pumps with hanger rods and spring hangers with vertical-limit stop of size required to support weight of in-line pumps. Comply with requirements for hangers and supports specified in other Division 23 Sections.

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. For separately-coupled end-suction or double-suction pumps, comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check valve and ball valve on each condensate pump unit discharge.

F. Ground equipment according to Division 26.

G. Connect wiring according to Division 26.

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3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service. Complete installation and startup checks according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 23 21 23

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SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sheet metal ducts and fittings.
2. Sheet metal materials.
3. Duct liner.
4. Rectangular duct connection systems.
5. Sealants and gaskets.
6. Hangers and supports.

B. Related Requirements

1. ANSI/SMACNA 006-2006 (SMACNA 006) HVAC Duct Construction Standards – Metal and Flexible Third Edition. All ductwork shall be in conformance with this standard.
2. Structural Performance: Duct hangers, supports, and seismic restraints (where applicable) shall withstand the effects of gravity, wind, and seismic loads and stresses within limits and under conditions described in SMACNA 006, ASCE/SEI 7, and local requirements.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.2 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by the Architect/Engineer. Accompany requests for layout modifications with calculations showing the proposed layout will provide original design results without increasing system total pressure.

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of the following products:

a. Prefabricated ductwork and fittings.
b. Liners and adhesives.
c. Rectangular duct connection systems.
d. Sealants and gaskets.

2. Shop Drawings:

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a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
b. Fittings, including details of construction.
c. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
d. Elevations of top and bottom of ducts along with applicable elevations of structural elements.
e. Dimensions of main duct runs from building grid lines.
f. Reinforcement and spacing.
g. Duct material and gauge thickness by pressure class.
h. Seam and joint construction.
i. Penetration details through fire-rated, smoke barriers and other rated partitions.
j. Equipment installation based on equipment being utilized on this project.
k. Duct accessories, including dampers, turning vanes, and duct access doors.
l. Length of application of acoustic duct liner where it will be applied.
m. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
n. Other systems installed in the same space as ducts where order of installation affects access.
o. Ceiling and wall mounted access doors and panels required to provide access to dampers, controls and other operating devices.
p. Ceiling mounted items, including light fixtures, diffusers, grilles, speakers, smoke detectors, sprinklers, other electrical devices, equipment and building structural members.
q. On each drawing, include a tabular list of each fan system's ductwork represented on that drawing and the total square foot surface area of each fan's duct system illustrated on the drawing.
r. Shop drawings shall be submitted prior to the fabrication or installation of the ductwork and serve as the foundation for coordination between various trades to maintain required ceiling heights.

3. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

a. Test procedures used.
b. Test results that comply with requirements.
c. Failed test results and corrective action taken to achieve requirements.

B. Leakage Testing Documentation: Contractor shall submit a written report to the authority having jurisdiction in which ducts designed at static pressures more than 3" wg pressure class have been leak tested and that the air leakage class is less than 6.0 per the Energy Code. Provide duplicate submittal to the Owner and the Engineer.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for steel hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum hangers and supports.

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3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance: Applicable requirements in:

1. NFPA 90A.
2. NFPA 90B.
3. NFPA 96.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1.

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Damage: Handle, transport, and store ducts to avoid damage. Damaged ductwork is not acceptable.

B. Protection: Protect ducts from mechanical damage, weather, and exposure to chemicals (including road salt). Do not permit insulation materials to get wet under any circumstances. Remove insulation that is or has been wet from the project site, and replace the insulation with undamaged new materials.

C. Ductwork and associated components shall be stored on blocking in a clean dry area to prevent damage and to prevent the entrance of dirt, debris, foreign matter and moisture.

D. Ductwork shall be adequately supported during storage to prevent sagging or bending.

E. Provide temporary storage, delivery and handling in accordance with SMACNA Duct Cleanliness for New Construction Guidelines, Intermediate Level.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA 006 based on indicated static-pressure class. The figure numbers below reference that standard.

1. Transverse Joint: Figure 2-1.
2. Longitudinal Seam: Figure 2-2.
3. Pressure Class Gage and Reinforcement: Table 2-1 through Table 2-52 and Figure 2-3 through Figure 2-18.
4. Elbow: Figure 4-2 (Use the following types only unless specifically approved by the Engineer.):

a. Type RE 1 (radius elbow).
b. Type RE 2 (square throat elbow with turning vanes).
c. Type RE 3 (radius elbow with vanes).
d. Type RE 5 (dual radius elbow).

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e. Type RE 6 (mitered elbow without turning vanes) only for angles not greater than 45 degrees.

5. Turning Vanes: Figures 4-3 and 4-4. Figure 4-9 short radius vanes in accordance with Chart 4-1 are acceptable.
6. Branch Connection:

a. Diverging Flow: Figure 4-5 (all types). Figure 4-6 (following types only):

1) 45-degree entry to rectangular branch.
2) 45-degree lead-in to round branch.
3) Conical connection.
4) Bellmouth connection.
5) Conical or bellmouth spin-in fitting only for pressure class 2” WG or less.

b. Converging Flow: Figure 4-5 (all types) and Figure 4-6 (all types). Conical or bellmouth spin-in fitting is acceptable only for pressure class 2” WG or less.

7. Offset, Transition, or Obstruction: Figure 4-7 (all types) and Figure 4-8 (Figure B and C). Do not use Figure 4-8 Figure A (pipe through duct), Figure D (mitered offsets around obstruction, or Figure E (split duct around obstruction) unless specifically approved by the Engineer.

2.2 SINGLE-WALL ROUND OR FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA 006 Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Eastern Sheet Metal.
b. FlaktGroup SEMCO.
c. Lindab Inc.
d. McGill AirFlow LLC.
e. Sheet Metal Connectors, Inc.

2. Transverse Joint: Figure 3-1 (all types).
3. Longitudinal Seam: Figure 3-2 (all types). Do not use type RL-5 (grooved seam pipe lock or flat lock), RL-6 (snaplock), RL-7 (snaplock), or RL-8 (snaplock) seam for duct over 1” WG pressure class. Fabricate round duct larger than 90-inch diameter with butt-welded longitudinal seam.
4. Pressure Class Gage and Reinforcement: Table 3-2 through Table 3-15 and Figure 3-3.
5. Elbow: Figure 3-4. Use centerline radius of 1.5 diameters for each elbow unless space constraints prevent a radius that large; in that event, the radius may be reduced to that indicated in Table 3-1 with mitered segments. If space constraints prevent a radius as large as indicated in Table 3-1, a mitered elbow with turning vanes similar to Figure 4-3 and Figure 4-4 may be used. Do not use an adjustable elbow for duct over 1” WG pressure class.

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6. Branch Connection with Diverging or Converging Flow: Figure 3-5 and Figure 3-6. All types are acceptable for pressure class 2" WG or less duct. For pressure class 3" WG or more duct, use 90-degree tee fitting with oval-to-round tap, 45-degree lateral fitting, conical fitting, or wye fitting. Reducers may be incorporated into the fitting. Use only factory-fabricated fittings, not saddles or field-fabricated taps, for pressure class 3" WG or more duct.
7. Offset, Transition, or Obstruction: Figure 4-7 and Figure 4-8 modified for round or flat oval duct. Do not use Figure 4-8 Figure A (pipe through duct), Figure D (mitered offsets around obstruction), or Figure E (split duct around obstruction) unless specifically approved by the Engineer.
8. Flat Oval: Figure 3-7 and applicable figures for equivalent round duct.

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA 006 for 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 A 653/A 653M.

1. Galvanized Coating Designation: G90 unless otherwise indicated.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

D. Reinforcement Shapes and Plates:
1. Steel Duct: ASTM A 36/A 36M, steel plates, shapes, and bars; black or galvanized.
2. Aluminum Duct: ASTM B209 alloy 6061-T6 members or steel members isolated from the aluminum with butyl rubber, neoprene, or EPDM gasket materials.
3. Other Duct Materials: Reinforcement materials compatible with the duct materials at contact points.

E. Tie Rods: Materials compatible with duct materials. Galvanized steel or stainless steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, and NAIMA AH124.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

a. Owens Corning.
b. CertainTeed Corporation: Insulation Group.
c. Johns Manville.
d. Knauf Insulation.

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2. 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. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy and registered by the EPA for use in HVAC systems.
4. Surface-Burning Characteristics: Flame-spread index no greater than 25 and smoke-developed index no greater than 50 when tested according to UL 723; certified by a nationally recognized testing laboratory.
5. Water-Based Liner Adhesive: Comply with NFPA 90A and with ASTM C 916.

    a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

    a. Aeroflex USA Inc.
    b. Armacell LLC.
    c. Rubatex International, LLC.

2. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
3. Surface-Burning Characteristics: Flame-spread index no greater than 25 and smoke-developed index no greater than 50 when tested according to UL 723; certified by a nationally recognized testing laboratory.
4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A. For indoor applications, adhesive with a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). complying with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. 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- or 0.135-inch diameter shank, length to suit depth of insulation indicated with integral galvanized carbon-steel washer.

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2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel, aluminum, or stainless steel (as appropriate); with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA 006 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 install liner in rectangular ducts with longitudinal liner joints at locations other than corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams.
7. 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.
8. 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. Lined duct following unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are 2500 fpm or more.
    d. Other locations as indicated.

9. Terminate liner with buildouts (metal hat sections) at dampers, turning vane assemblies, or other devices. Secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 RECTANGULAR DUCT CONNECTION SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ductmate Industries, Inc.
2. Hart & Cooley, Inc. Ward Industries.
3. McGill Airflow LLC.

B. Connection System: Rectangular duct transverse joint connection, reinforcement, and sealing system with roll-formed metal flanges, metal corner pieces, sealants, gaskets, and cleats.

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2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a flame-spread index no greater than 25 and a smoke-developed index no greater than 50 when tested according to UL 723; certified by a nationally recognized testing laboratory.

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. Sealant: Modified styrene acrylic.
3. Water resistant.
4. Mold and mildew resistant.
5. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
6. Service: Indoor and outdoor.
7. Service Temperature: Minus 40 to plus 200 deg F.
8. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
9. For indoor applications, sealant with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). For school projects, sealant complying with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). For school projects, sealant complying with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts or other materials compatible with duct materials.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods; galvanized rods with threads painted with zinc-chromate primer after installation; or stainless steel all-thread rods and nuts.

C. Strap and Rod Sizes: Comply with SMACNA 006 Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Cables:

1. Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
2. Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
3. End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Structural shapes and plates of materials compatible with duct materials and environmental conditions. Support material shall match duct construction material.

2.8 CASINGS

A. Fabricate casings according to SMACNA 1966 and construct for indicated operating pressures.

B. Doors:

1. Reinforce access door frames with steel angles tied to horizontal and vertical plenum supporting angles.
2. Furnish hinged access doors where indicated or required for access to equipment for cleaning and inspection.

C. Casings:

1. Fabricate acoustic casings with reinforcing turned inward.

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2. Furnish 18-gage back facing and front facing.
3. Construct panels 3 inches thick and packed with 4.5-pcf minimum glass-fiber media, on 16-gage inverted channels.

2.9 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Mason Industries.
6. TOLCO; a brand of NIBCO INC.
7. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized-steel or ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION GENERAL REQUIREMENTS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply ducts (before air terminal units): 4-inch wg.
2. Supply ducts (after terminal units): 2-inch wg.
3. Supply ducts (inside shafts): 6-inch wg.

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4. Return and outside air ducts (in mechanical equipment rooms and inside shafts) (negative pressure): 4-inch wg.
5. Return ducts (above ceiling): 2-inch wg.
6. General exhaust ducts (negative pressure): 2-inch wg.

B. 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 losses for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings or Coordination Drawings.

C. Install ducts according to SMACNA 006 unless otherwise indicated.

D. Unless otherwise indicated, install ducts vertically plumb or horizontally level, and parallel and perpendicular to building lines. Avoid diagonal runs to maximum extent possible.

E. Install ducts with a minimum clearance of 2 inch plus allowances for insulation thickness and access requirements.

F. Cable hangers may only be used on low pressure (2” wg construction and lower) round spiral ductwork which is not insulated and has a diameter 10” or less. Utilize the double lock method such that the lower loop is clinched tight to the ductwork and the cable is vertical. Utilize manufacturer’s top attachment device.

G. Provide duct offsets needed to avoid interferences with structure, finishes, piping, other ducts, conduit, etc. Coordinate the work with all trades to minimize such offsets. Install ducts with fewest joints possible.

H. Do not penetrate ducts with conduit or piping.

I. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

J. Secure couplings with sheet metal screws. Install screws at maximum intervals of 12”, with a minimum of 3 screws in each round metallic duct coupling.

K. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections. Do not field-cut taps for branch connections in ducts with SMACNA pressure class magnitude more than 2 in wg.

L. Install round or flat-oval ducts in maximum practical lengths to minimize joints.

M. Do not install any duct in an electrical equipment room unless that duct serves that room.

N. Do not install any duct in an elevator equipment room unless that duct serves that room.

O. Do not install any duct over an electrical transformer, electrical switchgear, or an electrical panel unless approved in writing by the Engineer.

P. Maintain clearances required in the National Electric Code for electrically-powered items.

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Q. Where ducts pass through interior partitions or 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 type and thickness as the duct. Overlap openings on all sides by at least 1-1/2 inches.

R. Where ducts pass through fire-rated partitions, install fire dampers unless otherwise indicated. Comply with requirements in other Division 23 Sections for fire dampers.

S. Where ducts pass through smoke partitions, install smoke dampers unless otherwise indicated. Comply with requirements in other Division 23 Sections for smoke dampers.

T. Install ductwork takeoffs at smoke dampers such that there is a minimum of 24” between the damper and the start of the first takeoff.

U. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts that are to be exposed in finished spaces from damage including dents, surface scratches, and markings. Exposed ducts must be undamaged and present a clean, neat appearance in materials and workmanship.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system in finished spaces.

C. Grind welds to provide smooth surfaces 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 the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets and inlets.

E. Repair or replace ducts that do not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hoods.

B. Install fire-rated access panel assemblies at each change in direction, at maximum intervals of 12 feet in horizontal ducts, at every floor penetration in vertical ducts, and elsewhere as indicated on Drawings. Locate access panel on top or side of duct a minimum of 1-1/2 inches from bottom of duct.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

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3.4 DUCT SEALING

A. In accordance with ASHRAE 90.1, seal all ducts to SMACNA 006 seal class A with all transverse joints, longitudinal seams, and duct wall penetrations sealed. Seal openings for rotating shafts (including dampers) with bushings or other devices. However, do not seal an opening if sealing the opening would void a manufacturer's listing. Spiral lock seams in round or flat oval ducts do not require sealing unless leakage is detected.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA 006 Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts**,** powder-actuated fasteners**,** or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA 006 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. Other types of hangers may be used if so indicated or if approved by Engineer.

E. Vertical Ducts: Support vertical ducts with steel angles or channel secured to the sides of the ducts with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet.

F. Upper Attachments: Install upper attachments secured to structural members. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials. Do not attach duct supports to roof decks.

G. Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, conduit, and piping

3.6 CONNECTIONS

A. Make connections to motorized equipment with flexible connectors complying with other Division 23 Sections. Comply with SMACNA 006 for branch, outlet, inlet, and terminal unit connections.

3.7 CASINGS

A. Floor Mounting:

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1. Install on 4 -INCH high concrete curbs as specified in Section 033000 - Cast-in-Place Concrete.
2. At floor, rivet panels to angles 8 inches o.c.
3. If floors are acoustically insulated, provide liner of 18-gage supported 12 inches o.c. and turned up 12 inches sides with sheet metal shields

3.8 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA "Seismic Restraint Manual: Guidelines for Mechanical Systems" or ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet on center and longitudinal supports a maximum of 80 feet on center.
2. Brace changes of direction longer than 12 feet (or less if local requirements indicate a shorter length).

B. Select seismic-restraint devices with capacities adequate to carry static and seismic loads.

C. Install cables so they do not bend across edges of adjacent items.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to building structural members such as flanges of beams, upper truss chords of bar joists, or concrete members.

G. Drilling for and Setting Anchors:

3.9 Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the

3.10 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a primer compatible with the duct material.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

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1. Comply with SMACNA "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test ductwork sections that have a design static pressure class magnitude of 4-inch wg or more regardless of duct locations. Test representative duct sections totaling no less than **25** percent of total installed duct area. Obtain Engineer's approval of specific sections to be tested beforehand.
3. Test all ductwork located outdoors.
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give at least seven days notice for testing.
8. Tests must demonstrate that tested ducts meet SMACNA leakage class 4 or less. If any tested section of ductwork fails to meet this requirement, perform the following at no additional cost to the Owner:

    a. Leak test 100 percent of the ductwork in every duct system with any failed section.
    b. Provide additional sealing of ductwork to eliminate excessive leakage in failed sections. If necessary, replace duct sections.
    c. Retest 100 percent of the ductwork in every duct system with any failed section.
    d. Continue sealing and retesting until the entire system is proven to meet the leakage requirement. Note that once a section is proven to meet the leakage requirement that section does not need to be tested again unless it is damaged later.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.12 DUCT CLEANING

A. Clean duct system(s) before testing, adjusting, and balancing in accordance with other Division 23 Sections.

3.13 DUCT CONSTRUCTION REQUIREMENTS

A. Fabricate ducts with materials, pressure classes, and insulations indicated on Drawings.

END OF SECTION 23 31 13

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SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Manual volume dampers.
2. Curtain-type fire dampers.
3. Multiple-blade type fire dampers.
4. Ceiling radiation dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Flange connectors.
8. Turning vanes.
9. Duct-mounted access doors.
10. Duct access panel assemblies.
11. Flexible connectors.
12. Duct security bars.
13. Duct accessory hardware.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.

a. For fire-dampers, smoke-dampers, combination fire- and smoke-dampers, and ceiling dampers include installation instructions.
b. For smoke-dampers and combination fire- and smoke-dampers include power, signal, and control wiring diagrams.

B. Closeout Submittals:

1. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

C. Maintenance Material Submittals:

1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

2. Fusible Links: Furnish quantity equal to at least 10 percent of amount installed.

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PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA 006 for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or Type 316 as indicated. Unless indicated otherwise, No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ruskin Company.
2. American Warming and Ventilating.
3. Greenheck Fan Corporation.
4. McGill Airflow LLC.
5. Nailor Industries Inc.
6. NCA.
7. Pottorff.
8. Safe Air – Dowco Products.
9. Vent Products Co., Inc.

B. Round Manual Volume Damper: Diameter 20 inches or less, air velocity 1500 fpm or less, and duct static pressure class 2-inch or less. Galvanized steel sleeve with reinforcing beads. Single

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galvanized steel blade on axle with molded synthetic bearing at each end of axle and locking quadrant on standoff bracket. Basis of design Ruskin MDRS25.

C. Round or Oval Manual Volume Damper: Diameter 48 inches or less, air velocity 4000 fpm or less, and duct static pressure class 10-inch or less. Galvanized steel construction for galvanized steel duct. Type 304 stainless steel construction for type 304 stainless steel or aluminum duct. Type 316 stainless steel construction for type 316 stainless steel duct. Rolled hat channel frame arranged for slip-in mounting. Single blade (or dual blades with center mullion for oval duct over 36 inches wide). Neoprene blade edge seals. Class II leakage rating. Blade mounted on axle with stainless steel sleeve bearing at each end of axle and locking quadrant on standoff bracket. Basis of design Ruskin CDR25 or CDO25.

D. Rectangular Manual Volume Damper: Height 12 inches or less, air velocity 1500 fpm or less, and duct static pressure class 1-inch or less. Galvanized steel sleeve with blade stop. Single galvanized steel blade on axle with molded synthetic bearings and locking quadrant on standoff bracket. Basis of design Ruskin MD25.

E. Rectangular Manual Volume Dampers: Height 5 inches or more, air velocity 1500 fpm or less., and duct static pressure class 3-inch or less. Galvanized steel hat channel frame with mitered and welded corners and blade stop. Flanged for attaching to wall and flangeless for installing in duct. Multiple single-thickness formed galvanized steel blades with opposed blade linkage enclosed in frame. Blades mounted on axles with molded synthetic bearings. Control shaft extended beyond frame with locking quadrant on standoff bracket. Basis of design Ruskin MD35.

2.4 CURTAIN-TYPE FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ruskin Company DIBD series.
2. American Warming and Ventilating.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. NCA.
6. Pottorff.
7. Safe Air – Dowco Products.
8. Vent Products Co., Inc.

B. Type: Static or dynamic as indicated on Drawings; rated and labeled according to UL 555.

C. Fire Damper Dynamic Closure Rating: At least 2000-fpm velocity for all sizes and mounting arrangements at 4-inch wg static pressure.

D. Fire Rating: 1-1/2 or 3 hours as indicated on Drawings.

E. Mounting Orientation: Vertical or horizontal as indicated.

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F. Frame and Blade Material: Galvanized steel (or stainless steel for aluminum or stainless steel duct).

G. Frame: Frame roll-formed in gages required by UL listing; with mitered and interlocking corners. Blade lock.

H. Blades: Roll-formed interlocking curtain blades operated by fusible link and stainless-steel closure spring. Link temperature rating 165 or 212 deg F as indicated on Drawings.

I. Mounting Sleeve: Factory-installed, galvanized steel in length required for installation. Steel mounting angles. Ends of sleeve act as duct collars for Style A or B. Integral duct collars at ends of sleeve for Style C, CR, or CO.

2.5 MULTIPLE-BLADE-TYPE FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ruskin Company DFD60 series.
2. American Warming and Ventilating.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. NCA.
6. Pottorff.
7. Safe Air – Dowco Products.
8. Vent Products Co., Inc.

B. Type: Dynamic; rated and labeled according to UL 555.

C. Fire Damper Dynamic Closure Rating: At least 2000-fpm velocity for all sizes and mounting arrangements at 4-inch wg static pressure.

D. Fire Rating: 1-1/2 or 3 hours as indicated.

E. Mounting Orientation: Vertical or horizontal as indicated.

F. Frame and Blade Material: Galvanized steel.

G. Frame: Hat channel frame, minimum 16 gage, with mitered and interlocking corners.

H. Blades: Single-piece airfoil blades equivalent to 14-gage strength, mounted on plated steel axles with permanently-lubricated stainless steel sleeve bearings pressed into frame. Parallel-blade-operation linkage concealed in frame.

I. Fusible Link: Temperature rating 165 or 212 deg F as indicated on Drawings.

J. Closure Spring: Stainless steel.

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K. Mounting Sleeve: Factory-installed, galvanized steel in length required for installation. Steel mounting angles. Ends of sleeve act as duct collars for Style A or B. Integral duct collars at ends of sleeve for Style C, CR, or CO.

2.6 CEILING RADIATION DAMPERS

1. Ruskin Company CFD series.
2. American Warming and Ventilating.
3. Nailor Industries Inc.
4. NCA.
5. Pottorff.
6. Safe Air – Dowco Products.

B. General Requirements:

1. Labeled according to UL 555C.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Heat-Responsive Device: Replaceable, 165 deg F or 212 deg F rated, fusible links.

F. Fire Rating: 1, 2, or 3 hours as indicated.

2.7 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ruskin Company SD60 series.
2. American Warming and Ventilating.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. NCA.
6. Pottorff.
7. Safe Air – Dowco Products.

B. General Requirements: Label according to UL 555S.

C. Damper Closure Rating: At least 2000-fpm velocity for all sizes and mounting arrangements at 4-inch wg static pressure.

D. Frame: Hat channel frame, minimum 16 gage, with mitered and interlocking corners.

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E. Blades: Single-piece airfoil blades equivalent to 14-gage strength, mounted on plated steel axles with permanently-lubricated stainless steel sleeve bearings pressed into frame. Parallel-blade-operation linkage concealed in frame.

F. Seals: Flexible stainless steel compression jamb seals. Silicone blade edge seals mechanically fastened to blades; suitable for temperatures 450 deg F or less.

G. Leakage: Class I.

H. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application; thickness to meet UL requirements.

I. Damper Motors: Modulating or two-position action as indicated.

J. Smoke Detector: Integral, factory wired for single-point connection.

K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in other Division 23 Sections.

L. Accessories:

1. Auxiliary switches for position indication.
2. Test and reset switches, damper or remote mounted as indicated.

2.8 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ruskin Company FSD60 series.
2. American Warming and Ventilating.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. NCA.
6. Pottorff.
7. Safe Air – Dowco Products.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S.

C. Damper Closure Rating: At least 2000-fpm velocity for all sizes and mounting arrangements at 4-inch wg static pressure.

D. Fire Rating: 1-1/2 or 3 hours as indicated.

E. Frame: Hat channel frame, minimum 16 gage, with mitered and interlocking corners.

F. Blades: Single-piece airfoil blades equivalent to 14-gage strength, mounted on plated steel axles with permanently-lubricated stainless steel sleeve bearings pressed into frame. Parallel-blade-operation linkage concealed in frame.

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G. Seals: Flexible stainless steel compression jamb seals. Silicone blade edge seals mechanically fastened to blades; suitable for temperatures 450 deg F or less.

H. Leakage: Class I.

I. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application; thickness to meet UL requirements.

J. Damper Motors: Modulating or two-position action as indicated.

K. Smoke Detector: Integral, factory wired for single-point connection.

L. Heat-Responsive Device: Resettable, 165 deg F or 212 deg F as indicated rated, fire-closure device and switch package, factory installed.

M. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in other Division 23 Sections.

N. Master control panel for use in dynamic smoke-management systems.

O. Accessories:

1. Auxiliary switches for position indication.
2. Test and reset switches, damper or remote mounted as indicated.

2.9 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ductmate Industries, Inc.
2. Ward Industries; a brand of Hart & Cooley, Inc.

B. Description: Add-on, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.10 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: 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.

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B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA 006.

D. Vane Construction: Single wall for vanes up to 48 inches wide and double wall for larger dimensions.

2.11 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA 006. Double wall, rectangular door. Galvanized sheet steel with insulation fill and thickness as indicated for duct pressure class. Butt or piano hinges and cam locks, quantities as indicated in SMACNA 006. Doors airtight and suitable for duct pressure class. Galvanized sheet steel frame with bend-over tabs and foam gaskets. Vision panel where indicated.

B. Pressure Relief Access Door: Door and frame of galvanized sheet steel. Double wall door with insulation fill and metal thickness applicable for duct pressure class. Open outward for positive-pressure duct and inward for negative-pressure duct. Factory set at 3.0-inch to 8.0-inch wg positive or negative. Door retaining device. Neoprene or foam rubber seal.

2.12 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Ductmate Industries, Inc.
2. Approved equal.

B. Labeled according to UL 1978. Double-wall panel with two layers of steel, minimum 11 gage (0.12-inch thick) carbon or 11 gage (0.13-inch) stainless, steel type to match duct material. Carbon or stainless steel panel fasteners welded to inner wall and attached by threaded fasteners to outer wall. Fasteners shall not penetrate duct wall. Gasket complying with NFPA 96; grease-tight and airtight, high-temperature ceramic fiber, rated for minimum 2000 deg F. Minimum pressure rating 10-inch wg, positive or negative.

2.13 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

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D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene. Minimum weight 26 oz./sq. yd. Minimum tensile strength 480 lbf/inch in the warp and 360 lbf/inch in the filling. Service temperature range minus 40 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone. Minimum weight 24 oz./sq. yd. Tensile strength 530 lbf/inch in the warp and 440 lbf/inch in the filling. Service temperature range minus 50 to plus 250 deg F.

2.14 DUCT SECURITY BARS

A. Configuration:

1. Frame: 2 by 1/4 inch flat frame with all joints fully welded.
2. Sleeve: 10 gage (0.1345-inch thick) continuously welded steel frames with 1-1/2-by-1-1/2-by-1/8-inch angle frame furnished loose for field welding to sleeve to be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
3. Bars: 1/2 inch diameter.
4. Bar Spacing: 6-inch centers in both directions. All bars welded into frame and welded at all intersection points.

2.15 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories in accordance with manufacturers' instructions.

B. Install duct accessories according to applicable details in SMACNA 006 for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

C. 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.

D. Compliance with ASHRAE/IESNA 90.1 restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft or control damper (as indicated) at inlet of exhaust fan or in exhaust duct close to exhaust fan unless otherwise indicated.

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E. Install volume dampers only in ducts constructed to magnitude 2" pressure class or less. Provide 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.

F. Set each damper fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated.

H. Install fire or smoke damper according to UL listing.

I. Install duct security bars. Connect duct security bars to ducts with flexible connections. Provide access door in duct on each side of sleeve.

J. 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 coil.
2. Upstream and downstream from duct filter.
3. At outdoor-air intake and mixed-air plenum.
4. At drain pan.
5. Downstream from manual volume damper, control damper, backdraft damper, and equipment.
6. Adjacent to and close enough to fire or smoke damper to reset or reinstall fusible link. Door for access to fire or smoke damper having fusible link shall be pressure relief access door and shall be outward operation for access door installed upstream from damper and inward operation for access door installed downstream from damper.
7. Upstream and downstream from duct silencer.
8. At each control device requiring inspection.
9. Elsewhere as indicated.

K. Install access door with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Two-Hand Access: 12 by 12 inches.
2. Head and Hand Access: 18 by 12 inches.
3. Head and Shoulders Access: 24 by 18 inches.
4. Body Access: 30 by 18 inches.
5. Body plus Ladder Access: 30 by 30 inches.
6. Where duct width does not permit door size specified above, one dimension of door size may be reduced to 2 inches less than duct width.

M. Label access door as specified in another Division 23 Section to indicate the purpose of the access door.

N. Install flexible connectors to connect ducts to equipment. If vibrating equipment is internally isolated from casing, provide rigid duct connections.

O. For fan developing static pressure of 5-inch wg or more, cover flexible connector with loaded vinyl sheet held in place with metal straps.

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P. Connect terminal unit to supply ductwork directly or with maximum 12-inch length of flexible duct. Do not use flexible duct to change directions or to correct misalignment of duct and terminal unit inlet.

Q. Connect diffuser or register to duct directly or with maximum 60-inch length of flexible duct clamped or strapped in place.

R. Connect flexible duct to metal duct with liquid adhesive plus tape.

S. Install duct test hole where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate each damper to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed and that door can open fully.
3. Operate fire, smoke, and combination fire and smoke damper to verify full range of movement and verify that proper heat-response or smoke-sensing device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operator to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

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SECTION 23 33 46 - FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulated flexible ducts.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.
2. Shop Drawings: For flexible ducts. Include plans showing locations and mounting and attachment details.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA 006 "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Comply with Air Diffusion Council "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Flexmaster U.S.A., Inc.
2. McGill Airflow LLC.
3. Thermaflex; a Flex-Tek Group.
4. Ward Industries; a brand of Hart & Cooley, Inc.

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B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-Value: R6.

C. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-Value: R6.

2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

B. Non-Clamp Connectors: Liquid adhesive plus tape.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA006 for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions or correct misalignments.

D. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with liquid adhesive plus tape or draw bands.

F. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Centerline radius of bends of flexible ducting shall not be less than one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns except as noted elsewhere.

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G. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches on center.

END OF SECTION 23 33 46

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SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Centrifugal roof ventilators.

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevation.

B. Operating Limits: Classify according to AMCA 99.

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

   a. Certified fan performance curves with system operating conditions indicated.
   b. Certified fan sound-power ratings.
   c. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   d. Material thickness and finishes, including color charts.
   e. Dampers, including housings, linkages, and operators.
   f. Roof curbs.

2. Seismic Qualification Data: Certificates for indoor, basic air-handling units, accessories, and components, from manufacturer.

   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Informational Submittals:

1. Field quality-control reports.

C. Closeout Submittals:

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1. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

D. Maintenance Material Submittals:

1. Belts: One spare set for each belt-driven unit.

1.4 QUALITY ASSURANCE

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. New York Blower Company.
4. PennBarry.
5. Twin City Fan & Blower.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Downblast Units: Provide spun-aluminum discharge baffle to direct discharge air downward.
2. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Direct Drive (Where Applicable): Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Belt Drives (Where Applicable):

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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. Pulleys: Cast-iron, adjustable-pitch motor pulley. Spring-loaded idler pulley for automatic belt tensioning.
5. Fan and motor isolated from exhaust airstream.

F. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or stainless steel wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. 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. Self-flashing without a cant strip configuration, with mounting flange.

1. Overall Height: 18 inches unless indicated otherwise.
2. Sloped Roof Mounting (Where Applicable): Manufacture curb for roof slope.
3. Burglar Bars: 1/2-inch-thick steel bars welded in place on 6-inch centers both directions.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors as indicated on Drawings and specified in another Division 23 Section. 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.

2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301. Factory test fans according to AMCA 300. Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210. Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans and accessories in accordance with manufacturer’s instructions.

B. Install power ventilators level and plumb.

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C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. Coordinate roof curb installation with General Contractor.

E. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 2 inches specified in another Division 23 Section.

F. Install units with clearances for service and maintenance.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Verify that shipping, blocking, and bracing are removed.
2. 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.
3. Verify that cleaning and adjusting are complete.
4. 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.
5. Adjust belt tension where applicable.
6. Adjust damper linkages for proper damper operation.
7. Provide and verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

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END OF SECTION 23 34 23

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SECTION 23 35 00

GAS DETECTION AND ALARM

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. This specification covers the furnishing and installation of materials for gas detection and alarm. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations.

1.2 DEFINITIONS

A. PIR: Photo acoustic- infrared.

1.3 SUBMITTALS

A. Product Data:

1. For each type of gas monitor, include sensing range in ppm, temperature and humidity range, alarm outputs, display range, furnished specialties, installation requirements, and electric power requirement.

B. Shop Drawings:

1. Air-Sampling Tubing: Size, routing, and termination including elevation above finished floor.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Product Certificates: For monitoring devices signed by product manufacturer.

D. Field quality-control test reports.

E. Operation and maintenance data.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Novar

B. Honeywell/Vulcain

C. Eastern Controls, Inc.

D. Macurco

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F. Armstrong Monitoring

G. Approved Equal

2.2 GAS MONITOR

A. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, shutting down fuel-fired equipment and automatically activating ventilation system.

B. ASHRAE: Monitoring system shall comply with ASHRAE 15 and ASHRAE 147.

C. Performance:

1. Gas to Be Monitored: Coordinate gas or refrigerant type with drawing or equipment manufacturers.

2. Range: 0 to 1000 ppm or as required for gas/refrigerant type

3. Accuracy: +/- 2% Full Scale

4. Linearity: +/- 1% Full Scale

5. Stability: +/- 2% Full Scale per year.

6. Response: 50% of change in less than 30 seconds.

7. Operating Temperature: 4 to 104 deg F (-20 to 40 deg C).

8. Relative Humidity: 0 to 95 percent, non-condensing over the operating temperature range. Compensate sensor for relative humidity.

9. Site Elevation: Maximum 6560 feet (2000 m).

D. Input/output Features:

1. Maximum Power Input: 120-V ac, 60 Hz, 75W.

2. Number of Air-Sampling Points: Four

3. Air-Sampling Point Inlet Filter: 0.10-micron filter element for each sampling point.

4. Air-Sampling Point Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms matched to sensor output.

5. Alarm Relays: Minimum 3 as directed relays at a minimum of 5-A resistive load each.

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6. Alarm Set Points: Displayed and adjustable through keypad on front of meter.

7. Alarm Silence Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.

8. Alarm Manual Reset: Momentary-contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.

9. Display: Alphanumeric LCD LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault/trouble LEDs.

10. Audible Output: Minimum 75 dB at 10 feet (3 m).

11. Visible Output: Strobe light.

12. Sensor Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.

13. Serial Output: RS-232 or RS-485 compatible with HVAC controls.

14. Enclosure: NEMA 250 as directed with locking quarter-turn latch and key.

2.3 MONITOR ALARM SEQUENCE

A. Refer to Sequence of Operation for HVAC Controls specification for operation.

D. Sensor Fault/Trouble: Notify HVAC control workstation of fault/trouble detection in monitor.

2.4 NOTIFICATION APPLIANCES

A. Horns: Comply with UL 464; electric-vibrating-polarized type, listed by a qualified testing agency with provision of housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 DBA, measured 10 feet (3 m) from the horn.

B. Visible Alarm Devices: Comply with UL 1971; three color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words “REFRIGERANT DETECTION” printed in minimum ½-inch- (13-mm-) high letters on the lens. Rated light output is 100, candela.

2.5 AIR-SAMPLING TUBING

A. Annealed-Temper Copper Tubing: ASTM B 88, Type L.

B. Polyethylene Tubing: ASTM D 2737, flame-retardant, nonmetallic tubing rated for ambient temperature range of 10 to 150 deg F (minus 13 to plus 65 deg C).

PART 3 – EXECUTION

3.1 INSTALLATION

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A. Comply with ASHRAE 15 and ASHRAE 147.

B. Install air-sampling inlets or diffusion type monitors in pits, tunnels, or trenches in machinery room that are accessible to personnel.

C. Floor mount diffusion-type monitor, sensor/transmitters, or air-sampling inlets on slotted channel frame 12 to 18 inches (300 to 450 mm) above the floor in a location near the refrigerant source or between the refrigerant source and the ventilation duct inlet.

D. Wall mount air-sampling multiple-point monitors with top of unit 60 inches (1525 mm) above finished floor.

E. Run air-sampling tubing from monitor to air-sampling point, in size as required by monitor manufacturer. Install tubing with maximum unsupported length of 36 inches (915 mm), for tubing exposed to view. Terminate air-sampling tubing at sampling point with filter recommended by monitor manufacturer.

F. Install air-sampling tubing with sufficient slack and flexible connections to allow for vibration of tubing and movement of equipment.

G. Purge air-sampling tubing with dry, oil-free compressed air before connecting to monitor.

H. Number-code or color-code air-sampling tubing for future identification and service of air-sampling multiple-point monitors.

I. Extend air-sampling tubing from exhaust part of multiple-point monitors to outside.

J. Install warning signs, labels, and nameplates to identify detection devices according to Division 15 Section “Mechanical Identification.”

3.2 FIELD QUALITY CONTROL

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

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.

2. Test and adjust controls and safeties.

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3. Test Reports: Prepare a written report to record the following:

a. Test procedures used.

b. Test results that comply with requirements.

c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Repair or replace malfunctioning units and retest as specified above.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant detection devices.

END OF SECTION 23 35 00

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SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes air terminal units.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of air terminal unit.

a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
c. Include diagrams for power, signal, and control wiring.

B. Informational Submittals:

1. Field quality-control reports.

C. Closeout Submittals:

1. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

D. Maintenance Material Submittals:

1. Fan-Powered-Unit Filters: Furnish **one** spare filters for each filter installed.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1.

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2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Trane.
2. Titus.
3. Enviro-Tec; by Johnson Controls, Inc.
4. Krueger.
5. Metalaire, Inc.
6. Nailor Industries Inc.
7. Price Industries.
8. York; a Johnson Controls company.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 22 gage (0.034-inch-thick) galvanized steel, single wall or double wall as indicated.

1. Casing Liner: As specified in "Casing Liner" Article below.
2. Air Inlet: Round stub connection or rectangular S-slip and drive connection for duct attachment.
3. Air Outlet: S-slip and drive connection.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Attenuator Section: Construction matching casing. Multi-outlet attenuator where indicated with multiple round collars, each with locking butterfly balancing damper.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings. Maximum damper leakage AHRI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Heating Coil: Type and locations as indicated. Coil as specified in Articles below.

F. Control devices compatible with temperature-control system specified in other Division 23 Sections.

1. Electronic Damper Actuator: 24 V modulating with position feedback.
2. Terminal Unit Controller: Pressure-independent DDC variable-air-volume (VAV) controller with electronic airflow transducer with multipoint averaging velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
3. Room Sensor: Wall mounted DDC with temperature set-point adjustment and access for connection of portable operator terminal.

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2.3 HYDRONIC HEATING COILS

A. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 10 fins per inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F.
1.

2.4 CASING LINER

A. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723.

B. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 1 inch.
2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA 006 and other Division 23 Sections.

B. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. 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.

3.2 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7, other Division 23 Sections, and local code requirements.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

3.3 TERMINAL UNIT INSTALLATION

A. Install air terminal units in accordance with manufacturer’s instructions.

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.4 CONNECTIONS

A. Where installing piping and ductwork adjacent to air terminal unit, allow space for service and maintenance.

B. Make duct connection to outlets of motorized air terminal units with flexible connectors or flexible ducts complying with requirements in other Division 23 Sections.

3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Sections for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 00

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SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.2 SUBMITTALS

A. Action Submittal:

1. Product Data: For each product indicated, include the following:

   a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   b. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

2. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   a. Ceiling suspension assembly members.
   b. Method of attaching hangers to building structure.
   c. Size and location of initial access module for acoustical tile.
   d. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   e. Duct access panels.

3. Color Samples for Initial Selection: For each product with factory-applied color finishes.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Titus.
2. Price.
3. Krueger.
4. Hart & Cooley.
5. Metalaire.
6. Tuttle & Bailey.

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7. AJ Manufacturing.
8. Gordon INC.

B. See drawing schedules, plans and details for required materials, finishes, style, sizes , pattern performance and accessories.
   1. Internal insulation of slot diffuser plenums is not allowed. All slot diffuser plenums shall be externally insulated.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be 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 practicable. 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.

D. Provide sponge rubber gasket, mounting frame, and concealed fastener mounting on all surface mounted grilles and registers.

E. Paint inside portion on all ductwork and plenums visible behind air device non-specular flat black enamel.

F. Provide additional support for grilles, registers, and diffusers mounted in lay-in ceiling.

G. Provide non-specular flat black steel blank-offs behind all unused portions of linear air devices.

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H. Coordinate exact location of Diffusers, Grilles and Registers with area smoke detectors, lights, and electrical devices. Air devices shall not be closer than 3 feet from area smoke detector.

I. Final location of diffusers, registers and grilles shall be from architectural reflected ceiling plans.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

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SECTION 23 52 16 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes gas-fired, fire-tube condensing boilers, trim, and accessories for generating heating hot water.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and 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.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

B. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

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1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONDENSING BOILER MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. AERCO.
2. BRYAN.
3. CLEAVER BROOKS.
4. FULTON.
5. LOCHINVAR.

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2017 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. Mounting Base: For securing boiler to concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 sections when mounting base is anchored to building structure.

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2.3 FIRE-TUBE CONDENSING BOILERS

A. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

B. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.

C. Pressure Vessel: Carbon steel with welded heads and tube connections.

D. Burner: Natural gas, forced draft.

E. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 sections 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.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

G. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

H. Casing:

1. Jacket: Sheet metal with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel protective finish.
4. Insulation: Minimum 2-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

2.4 TRIM

A. Aquastat Controllers: Operating, firing rate, and high limit.

B. Safety Relief Valve: ASME rated.

C. Pressure and Temperature Gage: Minimum 3-1/2-inch- diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

D. Boiler Air Vent: Automatic.

E. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

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2.5 CONTROLS

A. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.6 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to fused disconnect switch or nonfused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

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2.7 VENTING KITS

A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.8 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Equipment Mounting:
1. Comply with requirements for vibration isolation and seismic-restraint devices specified in Division 23 sections.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

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3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 sections.

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting:

1. Install flue venting kit and combustion-air intake.

I. Ground equipment according to Division 26 sections Connect wiring according to Division 26 sections

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspection with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

B. Boiler will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

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D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 23 52 16

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SECTION 23 55 23.13 - LOW-INTENSITY, GAS-FIRED, RADIANT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes low-intensity, gas-fired, radiant heaters.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.

    a. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

2. Shop Drawings:
    a. Include plans, elevations, sections, and mounting/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. Detail fabrication and assembly of low-intensity, gas-fired, radiant heaters, as well as procedures and diagrams.
    d. Include wiring diagrams for power, signal, and control wiring.

B. Informational Submittals:

1. Field quality-control reports.
2. Sample Warranty: For manufacturer's special warranties.

C. Closeout Submittals:

1. Operation and Maintenance Data: For gas-fired, radiant heaters to include in emergency, operation, and maintenance manuals.
2. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

    a. Igniter: One hot-surface burner igniter for each style of low-intensity, gas-fired, radiant heater furnished.

1.3 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period.

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1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.

    a. Burner Assembly: Three years.
    b. Combustion and Emitter Tubes: Two years.
    c. Heater Controls: One year.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. UL listed and labeled, with UL label clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.

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 FORCED-DRAFT HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Detroit Radiant Products Company.
2. Modine.
3. Roberts-Gordon, Inc.
4. Reznor.
5. Space-Ray; a division of Gas-Fired Products Inc.
6. Sterling.

B. Description: Factory-assembled, indoor, overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.

C. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

D. Burner Assembly:
1. Combustion-Air Inlet: Ducted horizontal to outdoors through sidewall with vent caps.
2. Combustion-Air Inlet: Ducted vertical to outdoors through roof with vent caps.
3. Burner Control Housing: Corrosion-resistant, aluminized steel.

    a. Totally enclosed with steel access cover.
    b. Sight glass for visual inspection of burner.
    c. Finish: Enameled finish.

4. Burner: Stainless steel.
5. Ignition System: Silicon carbide hot-surface igniter with flame rod sensing capabilities and self-diagnostic control module.

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6. Combustion Blower Fan: Dynamically balanced, direct-driven, forward-curved fan with cast-aluminum-alloy impeller and aluminized-steel housing, with a minimum temperature rating of 450 deg F.
7. Motors: General requirements for motors are specified in Division 23.

    a. Motor: Resilient-mounted, capacitor-start-capacitor-run type with sealed ball bearings; totally enclosed, nonventilated type with internal thermal protection.
    b. 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.

E. Combustion Chamber: 4-inch-diameter, 16-gage, aluminized-steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Chambers shall be equipped with sight glass for burner and pilot flame observation.

F. Emitter Tube: 4-inch-diameter, 16-gage, aluminized-steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Emitter tubing shall be equipped with baffles to maximize heating efficiency.

1. Tubing Connections: Stainless-steel threaded couplings.
2. 90-degree-bend emitter steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish.
3. Exhaust Vent Termination: Vertical through roof or horizontal though side wall with vent caps.

G. Reflector: Polished aluminum, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors or entire heater shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.

H. Accessories:

1. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees from vertical.
2. Protective grilles mounted to reflectors to protect emitter tubing.
3. Stainless-steel flexible connector with manual valve for gas supply.
4. Hanger chain with "S" hooks.
5. 3/16-inch-diameter, aluminized-steel wire tubing hangers and reflector supports.
6. Rigid mounting kits.
7. Outdoor use conversion kit.
8. Clearance warning plaque.

2.3 CONTROLS AND SAFETIES

A. Gas Control Valve: Two-stage, regulated redundant 24-V ac gas valve that contains pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

B. Failure Safeguards: 100 percent shutoff of gas flow in the event of flame or power failure.

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C. Prepurge of air control system prior to burner ignition.

D. Safety lockout of burner after three consecutive ignition failures.

E. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.

F. Control Panel Interlock: Stops burner if panel is open.

G. Indicator Lights: "Airflow-on" and "burner-on" indicator lights.

H. Thermostat: Devices and wiring are specified in other Division 23 Sections.

I. Thermostat: Two-stage, wall-mounted type with 50 to 90 deg F operating range and fan on switch.

1. Control Transformer: Integrally mounted.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for fuel-gas piping to verify actual locations of piping connections before equipment installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 INSTALLATION

A. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to NFPA 54.

B. Suspended Units: Suspend from substrate using chain hanger kits and building attachments.

1. Comply with requirements for hangers and supports specified in Division 23.

C. Maintain manufacturers' recommended clearances for combustibles.

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3.3 CONNECTIONS

A. Gas Piping: Comply with Division 23. Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service. Connect gas piping to radiant heaters according to NFPA 54.

B. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.

C. Vent Connections: Comply with Division 23.

D. Electrical Connections: Comply with applicable requirements in Division 26. Install electrical devices furnished with heaters but not specified to be factory mounted.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Gas-fired, radiant heaters will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial-temperature set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gas-fired, radiant heaters.

END OF SECTION 23 55 23.13

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SECTION 23 64 23 – SCROLL WATER CHILLERS

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. Packaged, water-cooled, electric-motor-driven, dedicated heat recovery scroll water chillers.

1.3 DEFINITIONS

A. DHRC: Dedicated Heat Recovery Chiller

B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.

E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

F. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

1.4 SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at ARI standard conditions and at conditions indicated.
2. Performance at ARI standard unloading conditions.

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3. Minimum evaporator flow rate.
4. Refrigerant capacity of water chiller.
5. Oil capacity of water chiller.
6. Fluid capacity of evaporator.
7. Fluid capacity of condenser.
8. Characteristics of safety relief valves.
9. Minimum entering condenser-water temperature.
10. Performance at varying capacity with constant design condenser-water temperature. Repeat performance at varying capacity for different condenser-water temperatures from design to minimum in 5 deg F increments.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Floor 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. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Certificates: For certification required in "Quality Assurance" Article.

E. Source quality-control test reports.

F. Startup service reports.

G. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

H. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 590 certification program.

B. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.

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2. ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.8 WARRANTY

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

1. Compressor Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED DEDICATED HEAT RECOVERY WATER-COOLED CHILLERS

A. Manufacturers: Subject to compliance with requirements, or a comparable product by one of the following:

1. ArctiChill.
2. Carrier
3. Chillit Company
4. MultiStack
5. Quantech.
6. Johnson Controls.

B. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.

C. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.

D. Compressors:

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1. Description: Positive-displacement direct drive with hermetically sealed casing.Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
2. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
3. Capacity Control: On-off compressor cycling.
4. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.

E. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

F. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

G. Refrigeration:

1. Refrigerant: R-134a or R-4110a.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

H. Evaporator:

1. Brazed-plate or shell-and-tube design, as indicated.
2. Shell and Tube:

    a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
    b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    c. Shell Material: Carbon steel.
    d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
    e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
    f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

3. Brazed Plate:

    a. Direct-expansion, single-pass, brazed-plate design.
    b. Type 316 stainless-steel construction.

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c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

I. Condenser:

1. Shell and Tube:

a. Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
b. Provides positive subcooling of liquid refrigerant.
c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
d. Shell Material: Carbon steel.
e. Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
g. Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.

J. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
2. House in a unit-mounted, NEMA 250, Type 1 enclosure with hinged access door with lock and key or padlock and key.
3. Wiring shall be numbered and color-coded to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field power interface shall be to NEMA KS 1, heavy-duty, non-fused disconnect switch.
6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
b. NEMA KS 1, heavy-duty, nonfusible switch.
c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
9. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
10. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
11. Control Relays: Auxiliary and adjustable time-delay relays.
12. Indicate the following for water chiller electrical power supply:

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a. Current, phase to phase, for all three phases.
b. Voltage, phase to phase and phase to neutral for all three phases.
c. Three-phase real power (kilowatts).
d. Three-phase reactive power (kilovolt amperes reactive).
e. Power factor.
f. Running log of total power versus time (kilowatt hours).
g. Fault log, with time and date of each.

K. Controls:

1. The DHRC shall be equipped with a micro-processor based controller. The DHRC shall have the capability to operate in response to either heating water or cooling water set points. The selection of these two modes of operation shall be made by the DHRC's Master Controller or, alternatively, this mode may be set manually, or through a binary input to the controller. The Chiller shall operate based on constant primary flow via the manufacturer provided, field installed and wired, pumps for the DHRC's condenser and evaporator flow.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

a. Date and time.
b. Operating or alarm status.
c. Operating hours.
d. Outside-air temperature if required for chilled-water reset.
e. Temperature and pressure of operating set points.
f. Entering and leaving temperatures of chilled water.
g. Entering and leaving temperatures of condenser water.
h. Refrigerant pressures in evaporator and condenser.
i. Saturation temperature in evaporator and condenser.
j. No cooling load condition.
k. Elapsed time meter (compressor run status).
l. Pump status.
m. Antirecycling timer status.
n. Percent of maximum motor amperage.
o. Current-limit set point.
p. Number of compressor starts.

4. Control Functions:

a. Manual or automatic startup and shutdown time schedule.
b. Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water temperature.
c. Current limit and demand limit.
d. Condenser-water temperature.
e. External water chiller emergency stop.
f. Antirecycling timer.
g. Automatic lead-lag switching.

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5. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

    a. Low evaporator pressure or high condenser pressure.
    b. Low chilled-water temperature.
    c. Refrigerant high pressure.
    d. High or low oil pressure.
    e. High oil temperature.
    f. Loss of chilled-water flow.
    g. Loss of condenser-water flow.
    h. Control device failure.

6. Failure to Run Mode (FRM): Chiller shall be capable of operation in the event that the Master Controller has lost communication. FRM provides the ability to switch the chiller into manual mode automatically keeping the chiller online until a replacement Master Controller can be provided. FRM requires a power phase monitor per module.

7. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor, control, and display water chiller status and alarms.

    a. BACnet communication interface with building management system shall enable building management system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building management system.

L. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
2. Thickness: 1 inch
3. Factory-applied insulation over cold surfaces of water chiller components.

    a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.

4. Apply protective coating to exposed surfaces of insulation.

M. Accessories:

1. Each inlet water header shall incorporate a built in 30-mesh (maximum) in-line strainer system to prevent heat exchanger fouling and accommodate 100% flow filtration with a minimum surface area of 475 sq inches per module.
2. Factory-furnished, chilled- and condenser-water flow switches for field installation.
3. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
4. Factory-furnished neoprene or spring isolators for field installation.
5. Factory furnished field installed and wired condenser and evaporator pumps.

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6. Factory furnished field installed and wired head pressure control valves

N. Capacities and Characteristics:

1. Refer to drawing.

2.2 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located indoors, rate sound power level according to ARI 575 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.2 WATER CHILLER INSTALLATION

A. Equipment Mounting: Comply with requirements for vibration isolation devices specified in Division 23.

1. Minimum Deflection: 1/4 inch.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

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D. Install separate devices furnished by manufacturer and not factory installed.

3.3 WATER TREATMENT REQUIREMENTS

A. Cycles of concentration shall be controlled such that recirculated water quality for modular Dedicated Heat Recovery Chillers using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:

1.	pH	Greater than 7 and less than 9
2.	Total Dissolved Solids (TDS)	Less than 1000 ppm
3.	Hardness as $CaCO_3$	30 to 500 ppm
4.	Alkalinity as Ca CO_3	30 to 500 ppm
5.	Chlorides	Less than 200 ppm
6.	Sulfates	Less than 200 ppm

3.4 CONNECTIONS

A. Comply with requirements in Division 23 Section "Hydronic Piping" Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Division 23 Section "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to chiller to allow service and maintenance.

D. Evaporator Fluid Connections: Refer to detail on drawings.

E. Condenser Fluid Connections Refer to detail on drawings.

F. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15.

G. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.

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4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-and condenser-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain water chillers

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END OF SECTION 23 64 23

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SECTION 23 64 23.13 - AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.

    a. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
    b. Performance at AHRI standard conditions and at conditions indicated.
    c. Performance at AHRI standard unloading conditions.
    d. Minimum evaporator flow rate.
    e. Refrigerant capacity of water chiller.
    f. Oil capacity of water chiller.
    g. Fluid capacity of evaporator.
    h. Characteristics of safety relief valves.
    i. Force and moment capacity of each piping connection.
    j. Minimum entering condenser-water temperature.
    k. Performance at varying capacity with constant design condenser-water temperature. Repeat performance at varying capacity for different condenser-water temperatures from design to minimum in 5 deg F increments.

2. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

    a. Assembled unit dimensions.
    b. Weight and load distribution.
    c. Required clearances for maintenance and operation.
    d. Size and location of piping and wiring connections.
    e. Diagrams for power, signal, and control wiring.

B. Informational Submittals:

1. Certificates: For certification required in "Quality Assurance" Article.
2. Seismic Qualification Data: Certificates, for water chillers, accessories, and components, from manufacturers.

    a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

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b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

3. Installation instructions.
4. Source quality-control reports.
5. Startup service reports.
6. Sample Warranty: For special warranty.

C. Closeout Submittals:

1. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
2. Spare Parts List: Recommended spare parts list with quantity for each.
3. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
4. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.3 EXTRA MATERIALS

A. Tool kit to include the following:

1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch high.
4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.

B. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.4 QUALITY ASSURANCE

A. AHRI Certification: Rate and certify chiller according to AHRI 550/590 certification program.

B. ASHRAE Compliance:

1. ASHRAE 15.
2. ASHRAE 90.1.
3. ASHRAE 147.

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C. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-134a refrigerant, include and ASME U-stamp and nameplate certifying compliance.

D. Comply with NFPA 70.

E. Comply with UL 465 at the specified short circuit rating.

F. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and oil.

B. Deliver chiller with protective crating or other covering.

1.6 WARRANTY

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

   a. Complete chiller including refrigerant and oil charge.
   b. Parts and labor.

2. Warranty Period: Five (5) years from the date of substantial completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Outdoor Installations:

1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.
2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period.

2.2 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Carrier.

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2. Daikin Applied.
3. MultiStack.
4. Quantech.
5. Trane.
6. York; a Johnson Controls company.

2.3 MANUFACTURED UNITS

A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.

2.4 CABINET

A. Base: Galvanized- or stainless-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.

B. Frame: Rigid galvanized- or stainless-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.

C. Casing: Galvanized- or stainless-steel.

D. Finish: Coat galvanized-steel base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.

2.5 COMPRESSOR-DRIVE ASSEMBLIES

A. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
4. Capacity Control: On-off compressor cycling with hot-gas bypass, if necessary, to achieve performance indicated. Digital compressor unloading is an acceptable alternative to achieve capacity control.
5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.
6. Vibration Isolation: Mount individual compressors on vibration isolators. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

B. Compressor Motors:

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1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

C. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, non-reversing.

2.6 REFRIGERATION

A. Refrigerant: R-410A. Classified as Safety Group A1 according to ASHRAE 34.

B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

C. Refrigerant Circuit: Each circuit shall include an electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

D. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

1. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.

E. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.

2.7 EVAPORATOR

A. Brazed-plate or shell-and-tube design, as indicated.

B. Shell and Tube:

1. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads with multi-pass baffles designed to ensure positive oil return and located at each end of the tube bundle.

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5. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

C. Brazed Plate:

1. Direct-expansion, single-pass, brazed-plate design.
2. Type 304 or 316 stainless-steel construction.
3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
4. Fluid Nozzles: Terminate with flange or mechanical-coupling end connections for connection to field piping.
5. Inlet Strainer: Factory-furnished, 40 mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.

D. Flow Switch: Factory-furnished, thermal-type flow switch wired to chiller operating controls.

E. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.

F. Remote-Mounting Kit: Designed for remote field mounting where indicated. Provide kit for field installation.

2.8 AIR-COOLED CONDENSER

A. Coils with integral subcooling on each circuit.

B. Plate Fin Coils: Construct coils of copper tubes mechanically bonded to aluminum fins.

C. Aluminum Microchannel Coils:

1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
2. Single- or multiple-pass arrangement.
3. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.

D. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

F. Fan Motors: Totally enclosed non-ventilated or totally enclosed air over enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.

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G. Fan Guards: Removable steel safety guards with corrosion-resistant coating.

2.9 INSULATION

A. Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C 534/C 534M, Type I for tubular materials and Type II for sheet materials.

1. Thickness: 3/4 inches.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
5. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.
6. Field-Applied Insulation:

    a. Components that are not factory insulated shall be field insulated to comply with requirements indicated.
    b. Manufacturer shall be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.
    c. Manufacturer's factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
    d. After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.10 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

C. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key.

D. Wiring shall be numbered and color-coded to match wiring diagram.

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E. Factory wiring outside of an enclosure shall be in raceway. Terminal connections shall be made with not more than a 24-inch length of liquid-tight or flexible metallic conduit.

F. Field power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch. Minimum short-circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 5,000 A.

G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:

1. NEMA KS 1, heavy-duty, non-fusible switch.

H. Each motor shall have overcurrent protection.

I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

J. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

K. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

L. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.

2.11 CONTROLS

A. Factory installed and wired, and functionally tested at factory before shipment.

B. The chiller shall be equipped with a micro-processor based controller. The chiller shall have the capability to operate in response to either heating water or cooling water set points. The selection of these two modes of operation shall be made by the chiller's Master Controller or, alternatively, this mode may be set manually, or through a binary input to the controller. The Chiller shall operate based on constant primary flow via the manufacturer provided, field installed and wired, pumps for the chiller's condenser and evaporator flow.

C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Chilled-water entering and leaving temperatures.
7. Heating Hot-water entering and leaving temperatures.
8. Refrigerant pressures in evaporator and condenser.

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9. Saturation temperature in evaporator and condenser.
10. No cooling load condition.
11. Elapsed time meter (compressor run status).
12. Antirecycling timer status.
13. Percent of maximum motor amperage.
14. Current-limit set point.
15. Number of compressor starts.
16. Alarm history with retention of operational data before unit shutdown.
17. Superheat.

E. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Capacity control based on evaporator leaving-fluid temperature.
3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
4. Chilled-water entering and leaving temperatures, control set points, and motor load limit.
5. Heating Hot-water entering and leaving temperatures, control set points, and motor load limit.
6. Current limit and demand limit.
7. Condenser-water temperature.
8. External water chiller emergency stop.
9. Antirecycling timer.
10. Automatic lead-lag switching.

F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator pressure or high condenser pressure.
2. Low chilled-water temperature.
3. Refrigerant high pressure.
4. High or low oil pressure.
5. High oil temperature.
6. Loss of chilled-water flow.
7. Loss of heating hot-water flow.
8. Control device failure.

G. BAS/DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.

1. Communication Interface: ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

H. Factory-installed wiring outside of enclosures shall be in NFPA 70-compliant raceway. Make terminal connections with liquid-tight or flexible metallic conduit.

2.12 ACCESSORIES

A. Factory-furnished vibration isolators with seismic restraints for field installation.

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2.13 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers before shipping.

C. Factory test and inspect evaporator according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. Rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.

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

3.2 WATER CHILLER INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.

C. Install water chillers on support structure indicated.

D. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Division 23.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

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H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled under the direct supervision of chiller manufacturer's factory-trained service personnel.

3.3 WATER TREATMENT REQUIREMENTS

A. Cycles of concentration shall be controlled such that recirculated water quality for modular Air- Chillers using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters:

1. pH Greater than 7 and less than 9
2. Total Dissolved Solids (TDS) Less than 1000 ppm
3. Hardness as $CaCO_3$ 30 to 500 ppm
4. Alkalinity as Ca CO_3 30 to 500 ppm
5. Chlorides Less than 200 ppm
6. Sulfates Less than 200 ppm

3.4 PIPING CONNECTIONS

A. Comply with requirements in Division 23 “Hydronic Piping”. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to chillers, allow space for service and maintenance.

C. Make connections to water chiller with flanges or mechanical couplings.

3.5 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Division 26 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Division 26 "Grounding and Bonding for Electrical Systems."

C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.6 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.

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C. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Division 23 "Direct Digital Control (DDC) System for HVAC."

D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak-tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device is properly vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions and provide electronic copy to Owner. Provide not less than eight hours of training.

END OF SECTION 23 64 23.13

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SECTION 23 73 13.13 - BASIC AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Factory-assembled, air-handling units with limited features.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each air-handling unit.

    a. Unit dimensions and weight. Include shipping splits and weight by segment. Include shipping and installed weights.
    b. Cabinet material, metal thickness, finishes, insulation thickness and density, and accessories.
    c. Fans:

        1) Certified fan-performance curves with system operating conditions indicated. Include flow, pressure drop, speed, brake HP, drive losses, and fan efficiency.
        2) Certified fan-sound power ratings.
        3) Fan construction and accessories (including belt guards, plenum fan cages, and piezometer rings).
        4) Motor ratings, electrical characteristics, and motor accessories. Include efficiencies and statement of VFD compatibility.
        5) Vibration isolation and restraint, including thrust restraints.

    d. Certified coil-performance ratings with system operating conditions indicated, tube thickness, fin thickness, and materials.
    e. Dampers, including housings, linkages, operators, and linkage ratings.
    f. Filters with performance characteristics including initial and final pressure drops at rated airflow. Include information on differential pressure gages and filter clips.
    g. Sound ratings for overall unit performance: Radiated sound, discharge air sound and entering air sound.
    h. Pressure drop across each segment of the air handling unit.
    i. Wiring diagrams: Power, signal and control wiring. Differentiate between factory-installed components and wiring and field-installed components and wiring.
    j. Electrical component information, including lights, receptacle, conduit and junction boxes.
    k. Access door construction, including door thickness, door operator type and material, handle locations and hinge information, thermal pane window information and test port locations.

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l. Drain pan construction with invert of drain pan dimensioned from the bottom of unit. Identify drain piping with trap heights detailed.
m. Airflow measuring probe calibration data.
n. Test reports on leakage and vibration.
o. All furnished specialties and accessories.
p. Installation and startup instructions include fan bearing lubrication schedule and requirements.

2. Seismic Qualification Data: Certificates for indoor, basic air-handling units, accessories, and components, from manufacturer.

a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Informational Submittals:

1. Source quality-control reports:
2. Field quality-control reports.

C. Closeout Submittals:

1. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.3 MAINTENANCE MATERIALS

A. Furnish additional materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set for each unit.
2. Gaskets: One set for each access door.
3. Final Fan Belts and Fan Sheaves: One set for each air-handling unit belt-driven fan sized by the test and balance contractor as required to deliver the necessary airflow through the system accounting for all system losses.
4. Paint: One quart-size can of touch-up paint for the exterior finish of each air handling unit provided.

1.4 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.5 QUALITY ASSURANCE AND PERFORMANCE REQUIREMENTS

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A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with ARI 410 for components, construction and rating. Certify coils to ARI 410.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

D. ASHRAE Compliance: Comply with applicable sections of the following:

1. ASHRAE 52.1.
2. ASHRAE 62.1.
3. ASHRAE 90.1.

E. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 6-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.005 inches/inch of panel span.

F. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: [1.5].

1.6 DELIVERY, STORAGE AND HANDLING

A. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions.

B. Protect, pack and secure control devices, motor control devices, and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

C. Enclose and protect control panels, electronic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.

D. Seal openings to protect against damage during shipping, handling, and storage.

E. Wrap indoor units with a tight sealing membrane. Wrapping membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Alternatively, AHU must be tarped for shipment and storage.

F. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust, and corrosion. Keep equipment clean and dry.

G. Tarp outdoor units to protect against rain and road debris during shipping.

H. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

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1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OUTDOOR, BASIC AIR-HANDLING UNIT MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. AAON.
2. Carrier Corporation; a unit of United Technologies Corp.
3. Daikin Applied.
4. Pace.
5. Trane.
6. York; a Johnson Controls company.

2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings;

A. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
B. Joints: Sheet metal screws or pop rivets.
C. Sealing: Seal all joints with water-resistant sealant. Hermetically seal at each corner and around entire perimeter.

B. Base Rail:

A. Material: Galvanized- or stainless-steel.
B. Height: 6 inches.

C. Double Wall:

A. Outside Casing Wall: Galvanized- or stainless-steel, minimum 18-gauge thickness, with manufacturer's standard finish.
B. Inside Casing Wall: Galvanized- or stainless-steel sheet, minimum 18-gauge thickness. Solid **or** perforated with mylar lining between perforated sheet and insulation.
C. Option: 22-gauge external/internal casing thickness will be acceptable in lieu of the above requirements if applied as part of an engineered panel construction using closed-cell insulation, and if the assembly meets pressure and rigidity requirements specified elsewhere in this section.

D. Floor Plate: Aluminum treadplate, minimum 0.1875” thick.

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E. Casing Insulation and Adhesive:

A. Materials:

1. ASTM C 1071, fiberglass with coated surface exposed to the airstream to prevent erosion of glass fibers.
2. Plastic insulation foamed-in-place between walls, urethane or polyisocyanurate.

B. Location and Application: Factory-applied insulation in all casing panels.

1. Adhesive (For Fiberglass): Comply with ASTM C 916, Type I complying with NFPA 90A.

C. Thickness: 2" minimum.
D. Thermal Resistance (R-Value): 12 hr-ft^2-°F/BTU minimum.

1. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
2. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke developed index of 50 when tested according to ASTM 411.

F. Static-Pressure Classifications:

A. For Unit Sections Upstream of Fans: Negative 4-inch wg.
B. For Unit Sections Downstream and Including Fans: Positive 6-inch wg.

G. Panels and Doors:

A. Panels:

1. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
2. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
3. Gasket: Neoprene, applied around entire perimeters of panel frames.
4. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 72 inches.

B. Doors:

1. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
2. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
3. Gasket: Neoprene, applied around entire perimeters of frame.
4. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 24 inches wide by full height of unit casing up to a maximum height of 72 inches.

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5. Provide temperature and pressure test ports in access doors between coils.

C. Locations and Applications:

1. Fan Section: Doors.
2. Coil Section: Panels.
3. Access Section: Doors.
4. Access Sections Immediately Upstream and Downstream of Coil Sections: Doors.
5. Damper Section: Doors.
6. Filter Section: Doors large enough to allow periodic removal and installation of filters.
7. Mixing Section: Doors.

H. Condensate Drain Pans:

A. Construction: Double walls of minimum 18-gauge stainless steel. Insulation between walls.
B. Drain Connection: Stainless steel drain connection located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple welded on one end of pan.
C. Slope: Minimum 0.125 in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers, and to direct water toward drain connection.
D. Length: Extend drain pan 12” downstream from leaving face of coil or to comply with ASHRAE 62.1.
E. Width: Entire width of water producing device.
F. Depth: 2 inches minimum.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

A. Shafts: With field-adjustable alignment.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at fan's maximum speed.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

A. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
B. Horizontal-Flanged, Split Housing: Bolted construction.
C. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.

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D. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch wide by 0.028-inch-thick, galvanized-steel or stainless-steel sheet.

1. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd.
2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.

D. Fan Shaft Bearings:

A. Self-aligning, pillow-block type with an L-50 rated life of minimum 200,000 hours according to ABMA 9.

E. Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and opposed blades constructed of two plates formed around and welded to shaft, with blades linked out of airstream to single control lever.

F. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch. Refer to other Division 23 sections for additional requirements.

G. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23.

A. Enclosure Type: Totally enclosed, fan cooled.
B. NEMA Premium Efficient motors as defined in NEMA MG 1.
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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
E. Mount unit-mounted disconnect switches on exterior of unit.

H. Variable-Frequency Motor Controller: Comply with Division 23.

2.4 COIL SECTION

A. General Requirements for Coil Section:

A. Comply with AHRI 410.
B. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coils.
C. Coils shall not act as structural component of unit.

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B. Preheat Coils:

A. Hot-Water Coils: Self-draining coil fabricated to ARI 410.

1. Piping Connections: Non-ferrous, threaded, on same end of coil.
2. Tube Material: Copper.
3. Fin Type: Plate.
4. Fin Material: Aluminum.
5. Fin Thickness: 0.0075 inches.
6. Fin and Tube Joint: Mechanical bond.
7. Headers: Seamless copper tube with brazed joints, prime coated with cleaning plugs.
8. Frames: Channel frame, minimum 0.052-inch-thick galvanized- or stainless-steel.
9. Coil Working-Pressure Ratings: 200 psig, 325 deg F.

C. Cooling Coils:

A. Chilled-Water Coil: Self-draining coil fabricated to ARI 410.

1. Piping Connections: Non-ferrous, threaded, on same end and extended 4" through exterior of unit.
2. Tube Material: Copper.
3. Tube Thickness: 5/8-inch O.D. copper, minimum 0.025-inch wall thickness.
4. Fin Type: Plate.
5. Fin Material: Aluminum.
6. Fin Thickness: 0.0075 inches.
7. Fin and Tube Joint: Mechanical bond.
8. Headers:
    1) Seamless copper tube with brazed joints, prime with cleaning plugs.
    2) Provide insulated cover to conceal exposed outside casings of headers.
9. Frames: Channel frame, stainless steel.
10. Working-Pressure Ratings: 200 psig, 325 deg F.

2.5 AIR FILTRATION SECTION

A. Particulate air filtration is specified in other Division 23 sections.

B. Panel Filters:

A. Description: Pleated factory-fabricated, self-supported disposable air filters with holding frames.
B. Filter Unit Class: UL 900.
C. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive.
D. Filter-Media Frame: High wet-strength beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Side-Access Filter Mounting Frames:

A. Particulate Air Filter Frames: Match inner casing and outer casing material,

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and insulation thickness. Galvanized steel track. Side access doors.

1. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.6 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

B. Damper Operators: Comply with requirements in other Division 23 sections.

C. Outdoor-Air, Relief-Air, and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed blade arrangement with zinc-plated steel operating rods rotating in nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

D. Blender Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section, designed to minimize temperature stratification.

E. Combination Filter and Mixing Section:

A. Cabinet support members shall hold 2-inch- thick, pleated, flat throwaway filters.
B. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.7 CONTROLS

A. Unit shall have controls installed by manufacturer. Controls may be installed in the field or at the factory
B. Unit shall have bacnet card provided with unit.
C. Unit shall have controls tested, either in the field or at the factory.
D. Control equipment and sequence of operations are specified in Division 23.

2.8 MATERIALS

A. Steel:

1. ASTM A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A 240/A 240M for bare steel exposed to

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airstream or moisture.

C. Galvanized Steel: ASTM A 653/A 653M.

D. Aluminum: ASTM B 209.

2.9 ACCESSORIES

A. Service LED Lights and Switch: Factory installed in each accessible section with weatherproof cover.

2.10 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

1. AMCA 210 Compliance: Fan performance according to AMCA 210.

B. AMCA 300 and AMCA 301, or AHRI 260 Certification: Air-handling unit fan sound ratings shall comply with AMCA 300, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data" and AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or with AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

C. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Examine casing insulation materials and filter media before air-handling unit installation. Replace materials that are wet, moisture damaged, or mold damaged.

B. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division

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2. Comply with requirements for vibration isolation and seismic-control devices specified in Division 23.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

D. If air-handling unit fans are not internally vibration-isolated, connect ducts to air-handling units with flexible connections. Comply with requirements in Division 23.

E. Connect duct to air-handling units with flexible connections unless fans are internally vibration- isolated. Comply with requirements in other Division 23 sections.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Division 26.

B. Ground equipment according to Division 26.

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

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection. Nameplates shall be laminated acrylic or melamine plastic signs with a 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 according to Division 26.

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3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete.
4. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
5. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
6. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory- recommended lubricants.
7. Verify that dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric coils.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.

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2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 for air-handling system testing, adjusting, and balancing.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling unit and air-distribution systems, and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13.13

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SECTION 23 74 33 –DEDICATED OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Factory-assembled, indoor air-handling units with limited features.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product:

a. Unit dimensions and weight. Include shipping splits and weight by segment. Include shipping and installed weights.
b. Cabinet material, metal thickness, finishes, insulation, and accessories.
c. Fans:

1) Certified fan-performance curves with system operating conditions indicated. Include flow, pressure drop, speed, brake HP, drive losses, and fan efficiency.
2) Certified fan-sound power ratings.
3) Fan construction and accessories (including belt guards, plenum fan cages, and piezometer rings).
4) Motor ratings, electrical characteristics, and motor accessories. Include efficiencies and statement of VFD compatibility.
5) Vibration isolation and restraint, including thrust restraints.

d. Certified coil-performance ratings with system operating conditions indicated, tube thickness, fin thickness, and materials.
e. Dampers, including housings, linkages, operators, and linkage ratings.
f. Filters with performance characteristics including initial and final pressure drops at rated airflow. Include information on differential pressure gages and filter clips.
g. Sound ratings for overall unit performance: Radiated sound, discharge air sound and entering air sound.
h. Pressure drop across each segment of the air handling unit.
i. Wiring diagrams: Power, signal and control wiring. Differentiate between factory-installed components and wiring and field-installed components and wiring.
j. Electrical component information, including lights, receptacle, conduit and junction boxes.
k. Access door construction, including door thickness, door operator type and material, handle locations and hinge information, thermal pane window information and test port locations.
l. Drain pan construction with invert of drain pan dimensioned from the bottom of unit. Identify drain piping with trap heights detailed.
m. Airflow measuring probe calibration data.

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n. Test reports on leakage and vibration.
o. All furnished specialties and accessories.
p. Installation and startup instructions include fan bearing lubrication schedule and requirements.

B. Informational Submittals:

1. Seismic Qualification Certificates: For dedicated outdoor-air units, accessories, and components, from manufacturer.

a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

2. Source quality-control reports.
3. Field quality-control reports.

C. Closeout Submittals:

1. Operation and Maintenance Data: For units to include in emergency, operation, and maintenance manuals.

D. Maintenance Material Submittals:

1. Furnish additional materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

a. Filters: One set for each unit.
b. Gaskets: One set for each access door.
c. Final Fan Belts and Fan Sheaves: One set for each air-handling unit belt-driven fan sized by the test and balance contractor as required to deliver the necessary airflow through the system accounting for all system losses.
d. Paint: One quart-size can of touch-up paint for the exterior finish of each air handling unit provided.

1.3 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.4 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.

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B. Comply with AHRI 410 for components, construction and rating. Certify coils to AHRI 410.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

D. ASHRAE Compliance: Comply with applicable sections of the following:

1. ASHRAE 52.1.
2. ASHRAE 62.1.
3. ASHRAE 90.1.

E. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 6-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.005 inches/inch of panel span.

F. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: [**1.5**].

1.5 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

B. AHRI 1060 Certification: Air-handling units that include air-to-air energy recovery devices shall be factory tested according to AHRI 1060 and shall be listed and labeled by AHRI.

C. AMCA 301 or AHRI 260: Air-handling unit fan sound ratings shall comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

D. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

E. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

F. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

G. Witnessed Casing Leakage Tests:

1. Pay for all expenses, for one representative designated by Owner, to travel to the factory to witness cabinet air-leakage testing on the specific assembled unit(s) prior to release for delivery to Project site.

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2. If the unit(s) does not meet specified leakage requirements, perform factory modifications and retest. Do not release unit for shipment until tested leakage is measured to be within specified leakage and leakage testing report has been accepted by Owner's designated representative.

1.6 DELIVERY, STORAGE AND HANDLING

A. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions.

B. Protect, pack and secure control devices, motor control devices, and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

C. Enclose and protect control panels, electronic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.

D. Seal openings to protect against damage during shipping, handling, and storage.

E. Wrap indoor units with a tight sealing membrane. Wrapping membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Alternatively, AHU must be tarped for shipment and storage.

F. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust, and corrosion. Keep equipment clean and dry.

G. Tarp outdoor units to protect against rain and road debris during shipping.

H. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. AAON.
2. Carrier Corporation; a unit of United Technologies Corp.
3. Daikin Applied.

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4. Miller Picking.
5. Trane.
6. YORK; a Johnson Controls company.
7. Annexair

2.2 UNIT CASING

A. Cabinet Deflection Performance:

1. Walls and roof deflection within 1/200 of the span at the design working pressure equal to the fan shut-off pressure. Deflection limits measured at any point on the surface.
2. Floor deflections within 1/240 of the span considering the worst-case condition caused by the following:

    a. Service personnel.
    b. Internal components.
    c. Design working pressure defined for the walls and roof.

B. Construction: Double wall.

C. Outside Casing Wall: Galvanized- or stainless-steel, minimum 18-gauge thickness, with manufacturer's standard finish.

D. Inside Casing Wall: Galvanized- or stainless-steel sheet, minimum 18-gauge thickness. Solid or perforated with mylar lining between perforated sheet and insulation.

E. Option: 22-gauge external/internal casing thickness will be acceptable in lieu of the above requirements if applied as part of an engineered panel construction using closed-cell insulation, and if the assembly meets pressure and rigidity requirements specified elsewhere in this section.

F. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.

G. Base Rails: Galvanized-steel rails for mounting on roof curb or pad as indicated.

H. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.

I. Service Doors: Hinged access doors with gaskets. Material and construction of doors shall match material and construction of cabinet in which doors are installed.
1. Provide temperature and pressure test ports in access doors between coils.

J. Roof: Standing seam or membrane; sloped to drain water.

K. Floor: Reinforced, treadplate, minimum 0.1875” thick metal surface; reinforced to limit deflection when walked on by service personnel. Insulation below metal walking surface.

L. Cabinet Insulation:

1. Materials: ASTM C 1071, fiberglass with coated surface exposed to the airstream to prevent erosion of glass fibers.
2. Casing Panel R-Value: Minimum R-12.

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3. Insulation Thickness: 2 inches.
4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

M. Condensate Drain Pans:

1. Shape: Rectangular, with 1 percent slope in at least two planes to direct water toward drain connection.
2. Size: Large enough to collect condensate from cooling coils including coil piping connections, coil headers, and return bends.

    a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
    b. Depth: A minimum of 2 inches deep.

3. Configuration: Single wall with ½" thick foam insulated bottom.
4. Material: Stainless-steel sheet.
5. Drain Connection:

    a. Located on one end of pan, at lowest point of pan.
    b. Terminated with threaded nipple.
    c. Minimum Connection Size: NPS 1.

6. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

7. Drain pans shall be field tested under normal operating conditions to ensure proper drainage or certified (attested in writing) by the manufacturer for drainage when installed as recommended.

N. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1 for resistance to mold and erosion.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
1. Shafts: With field-adjustable alignment.
    a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    b. Designed to operate at no more than 70 percent of first critical speed at fan's maximum speed.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.

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4. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch wide by 0.028-inch-thick, galvanized-steel or stainless-steel sheet.
   a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
      1) Fabric Minimum Weight: 26 oz./sq. yd.
      2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
      3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans. Direct drive.

D. Fan Shaft Bearings:
1. Self-aligning, pillow-block type with an L-50 rated life of minimum 200,000 hours according to ABMA 9.

E. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch. Refer to other Division 23 sections for additional requirements.

F. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23.
1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Mount unit-mounted disconnect switches on exterior of unit.
6. A Motor removal rail shall be factory provided and installed above the fan section.

G. Variable-Frequency Drive (VFD): Shall be factory mounted and wired to direct drive plenum fans. Include shaft grounding ring.

2.4 COIL SECTION

A. General Requirements for Coil Section:
1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coils.
3. Coils shall not act as structural component of unit.

B. COOLING COILS
1. Piping Connections: Non-ferrous, threaded, on same end and extended 4” through exterior of unit.
2. Tube Material: Copper.
3. Tube Thickness: 5/8-inch O.D. copper, minimum 0.025-inch wall thickness.
4. Fin Type: Plate.
5. Fin Material: Aluminum.

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6. Fin Thickness: 0.0075 inches.
7. Fin and Tube Joint: Mechanical bond.
8. Headers:
   a. Seamless copper tube with brazed joints, prime with cleaning plugs.
   b. Provide insulated cover to conceal exposed outside casings of headers.
9. Frames: Channel frame, stainless steel.
10. Working-Pressure Ratings: 200 psig, 325 deg F.

C. HOT-WATER HEATING COIL
1. Piping Connections: Non-ferrous, threaded, on same end of coil.
2. Tube Material: Copper.
3. Fin Type: Plate.
4. Fin Material: Aluminum.
5. Fin Thickness: 0.0075 inches.
6. Fin and Tube Joint: Mechanical bond.
7. Headers: Seamless copper tube with brazed joints, prime coated with cleaning plugs.
8. Frames: Channel frame, minimum 0.052-inch-thick galvanized- or stainless-steel.
9. Coil Working-Pressure Ratings: 200 psig, 325 deg F.

2.5 FIXED-PLATE TOTAL HEAT EXCHANGERS

A. Provide cross flow flat plate heat exchanger with performance as scheduled. Counter flow heat exchangers are not acceptable.

B. Plates: Heat Exchanger plates shall be completely smooth with no dimples or corrugations.
1. Heat Exchanger shall have aluminum tube framing. Steel framing is not acceptable. Plate shall be aluminum.
2. Plate corners must be sealed both mechanically and with sealant to limit cross contamination.
3. Entire heat transfer surface shall be visible for inspection and cleaning without disassembling the heat exchanger.
4. Provide double sloped stainless steel drain pans under entire heat exchanger.
5. A (10) year non-prorated parts warranty shall be provided for all flat plate air to air heat exchangers. The warranty shall begin at start up, or six months after shipment, whichever comes first.

2.6 FILTERS

A. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Located upstream of the fixed plate heat exchanger.
3. Factory-fabricated, viscous-coated, flat-panel type.
4. Thickness: 2 inches.
5. Minimum MERV: 8, according to ASHRAE 52.2.
6. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.

B. Mounting Frames:

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1. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.
2. Extended surface filters arranged for flat orientation, removable from access plenum.
3. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

2.7 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

B. Damper Operators: Comply with requirements in other Division 23 sections.

C. Outdoor-Air, Relief-Air, and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed blade arrangement with zinc-plated steel operating rods rotating in nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

D. Combination Filter and Mixing Section:
1. Cabinet support members shall hold 2-inch- thick, pleated, flat throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.8 ELECTRICAL POWER CONNECTIONS

A. General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.

B. Wiring: Numbered and color-coded to match wiring diagram.

C. Wiring Location: Install factory wiring outside an enclosure in a raceway.

D. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

E. Factory-Mounted, Overcurrent-Protection Service: For each motor.

F. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

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G. Controls: Factory wire unit-mounted controls and control transformer.

H. Lights: Factory wire unit-mounted LED lights.

I. Receptacle: Factory wire unit-mounted, ground fault interrupt (GFI) duplex receptacle.

J. Control Relays: Auxiliary and adjustable time-delay relays.

2.9 CONTROLS

A. DOAS unit controls to be provided by unit manufacturer with complete control system to include all devices, control panels, wiring, programming, and commissioning. DOAS Units are to operate standalone and must be capable of standalone operation in the event of a communication failure with the TCC. The controls provided by the DOAS unit manufacturer shall be responsible for enacting a sequence to provide frost control on the integral airside heat recovery heat exchanger. The DOAS unit provided controls shall be responsible for making available to the TCC via the BACnet connection any and all alarm points necessary to prevent a freeze up or failure of any kind in the DOAS unit. DOAS units are to have a BACnet connection at the control panel for setpoint adjustment by the TCC via a BACnet connection. The BACnet connection shall be as defined by the ASHRAE 135 standard. Control valves shall be provided by the DOAS manufacturer for field piping by the installing contractor. Any sensors, such as building pressurization sensors, that require remote mounting shall be installed and wired back to the DOAS unit mounted controller by the TCC, as specified by the DOAS manufacturer. On site commissioning, as required, shall be by the DOAS unit manufacturer.

B. Controls may be installed either in the field or at the factory. Intent is for product manufacturer to handle any problems or equipment failures that may arise from the controls they have provided with the unit.

C. Unit shall have controls tested, either in the field or at the factory.

D. Control equipment and sequence of operations are specified in Division 23.

E.

2.10 ACCESSORIES

A. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

B. Duplex Receptacle: Factory mounted in unit supply-fan section and refrigeration section, with 20-amp 120 V GFI duplex receptacle and weatherproof cover factory wired for single point power connection to entire unit.

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PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine casing insulation materials and filter media before air-handling unit installation. Replace materials that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Equipment Mounting:

1. Install air units on cast-in-place concrete equipment bases.
2. Comply with requirements for vibration isolation and seismic control devices specified in Division 23.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

D. If air-handling unit fans are not internally vibration-isolated, connect ducts to air-handling units with flexible connections. Comply with requirements in Division 23.

E. Connect duct to air-handling units with flexible connections unless fans are internally vibration-isolated. Comply with requirements in other Division 23 sections.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

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3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Division 26.

B. Ground equipment according to Division 26.

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

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection. Nameplates shall be laminated acrylic or melamine plastic signs with a 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 according to Division 26.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
   2. Charge refrigerant coils with refrigerant and test for leaks.
   3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify that shipping, blocking, and bracing are removed.
   3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete.
   4. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.

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5. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
6. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
7. Verify that dampers open and close, and maintain minimum outdoor-air setting.
8. Comb coil fins for parallel orientation.
9. Verify that proper thermal-overload protection is installed for electric coils.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 for air-handling system testing, adjusting, and balancing.

3.9 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling unit and air-distribution systems, and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 74 33

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SECTION 23 81 26 – DUCTLESS SPILT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes single zone and multi-zone ductless split systems with matched variable speed condensing units.

1.2 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product include:

    a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units.
    b. Rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
    c. Operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
    d. Description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
    e. System operating sequence of operation in narrative form for each unique indoor- and outdoor-unit.
    f. Description of control software features.
    g. Total refrigerant required, and a comprehensive breakdown of refrigerant required by each system installed.
    h. Refrigerant type and data sheets showing compliance with requirements indicated.
    i. System design software information.
    j. Indication of location and type of service access.

2. Shop Drawings: For ductless split systems.

    a. Include plans, elevations, sections, and mounting 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.

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c. 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.
d. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
e. Include diagrams for power, signal, and control wiring.

3. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants. Include a sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

B. Informational Submittals:

1. Qualification Data:

a. For Installer: Certificate from ductless split system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation. Retain copies of Installer certificates on-site and make available on request.
b. For ductless split system manufacturer.
c. For ductless split system provider.

2. Source quality-control reports.
3. Field quality-control reports.
4. Sample Warranties: For manufacturer's warranties.

C. Closeout Submittals:

1. Operation and Maintenance Data: For ductless split systems to include in emergency, operation, and maintenance manuals.
2. Software and Firmware Operational Documentation:

a. Software operating and upgrade manuals.
b. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
c. Device address list.
d. Printout of software application and graphic screens.

3. Extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

a. Filters: One set for each unit.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:

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1. Nationally recognized manufacturer of ductless split systems and products.
2. Shipped ductless split systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. Ductless split systems and products that have been successfully tested and in use in at least five completed projects.
4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
5. ISO Compliance: System equipment and components furnished by ductless split system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

B. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, ductless split system manufacturer.
2. Demonstrated experience on projects of similar complexity, scope, and value. Each person assigned to Project shall have demonstrated experience.
3. Service and maintenance staff assigned to support Project during warranty period.
4. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by ductless split system manufacturer.

1. Each Installer certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.

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. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory.

F. ASHRAE Compliance: Comply with applicable requirements in:

1. ASHRAE 15.
2. ASHRAE 62.1.
3. ASHRAE/IES 90.1.
4. ASHRAE 135: For control network protocol with remote communication.

G. UL Compliance: Comply with UL 1995.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

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C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit. Remove and replace products that are wet, moisture damaged, or mold damaged.

E. Replace installed products damaged during construction.

F. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressors: 10 years from date of Substantial Completion.
b. For Parts, Including Controls: 10 years from date of Substantial Completion.
c. For Labor: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Carrier / Toshiba
2. Daikin AC (Americas), Inc.
3. Lennox
4. LG
5. Trane / Mitsubishi Electric & Electronics USA, Inc.
6. Panasonic
7. Samsung.
8. York, a Johnson Controls company.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) ductless split system with variable capacity in response to varying cooling and heating loads. System shall consist of outdoor unit with single or multiple indoor

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units. Provide all piping, controls, and electrical power to make complete operating systems complying with requirements indicated.

1. System operation, air-conditioning, or heat pump as indicated.
2. Each system with one refrigerant to each indoor unit connected to system.

2.3 PERFORMANCE REQUIREMENTS

A. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Engineer for direction. The most stringent requirements should apply unless otherwise directed in writing by Engineer.

B. Isolation of Equipment: Provide isolation valves to isolate each indoor unit for service, removal, and replacement without interrupting system operation.

C. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the range of not less than 50 percent to not more than 150 percent of outdoor-unit rated capacity or greater range if acceptable to system manufacturer.

D. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

E. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

F. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.

    a. Design equipment and supports to withstand snow and ice loads of governing code and ASCE/SEI 7.
    b. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: See Drawings.
3. Minimum System Operating Outdoor Temperature: See Drawings.

G. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
2. Outdoor: Within ordinance of governing authorities.

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H. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

2.4 INDOOR, EXPOSED, WALL-MOUNTED UNITS

A. Description: Factory-assembled complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
d. Wheels statically and dynamically balanced.

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2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 8.
3. Media: Replaceable extended surface, panel, or cartridge with antimicrobial treatment fiber media.

G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top or front face of unit cabinet.

H. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

I. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Unit inlet air temperature.
    b. Coil entering refrigerant temperature.
    c. Coil leaving refrigerant temperature.

4. Features and Functions:

    a. Self-diagnostics.
    b. Time delay.
    c. Auto-restart.
    d. Auto operation mode.
    e. Manual operation mode.
    f. Filter service notification
    g. Power consumption display.
    h. Drain assembly high water level safety shutdown and notification.
    i. Run test switch.

5. Communication: Network communication with other indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

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J. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.5 INDOOR, RECESSED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Internal Tubing: Copper tubing with brazed joints.
6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

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1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, to accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 8.
3. Media: Replaceable extended surface, panel, or cartridge with antimicrobial treatment fiber media.

G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.

1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.

    a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
    b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.

H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.

J. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

K. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
1. Factory-Installed Sensors:

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a. Unit inlet air temperature.
b. Coil entering refrigerant temperature.
c. Coil leaving refrigerant temperature.

1. Features and Functions:

a. Self-diagnostics.
b. Time delay.
c. Auto-restart.
d. Auto operation mode.
e. Manual operation mode.
f. Filter service notification
g. Power consumption display.
h. Drain assembly high water level safety shutdown and notification.
i. Run test switch.

2. Communication: Network communication with other indoor units and outdoor unit(s).
3. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
4. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.6 OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.

B. Cabinet:

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1. Galvanized steel and coated with a corrosion-resistant finish. Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.
2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressors with inverter drive and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:

    a. High refrigerant pressure.
    b. Low oil level.
    c. High oil temperature.
    d. Thermal and overload.
    e. Voltage fluctuations.
    f. Phase failure and phase reversal.
    g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:

    a. Casing: Aluminum, galvanized, or stainless steel.
    b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
    c. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:

    a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
    b. Single- or multiple-pass arrangement.
    c. Construct fins, tubes, and header manifolds of aluminum alloy.

3. Corrosion Protection: Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

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1. Fans: Propeller type.

    a. Direct-drive arrangement.
    b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
    c. Dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motors: Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Refrigerant suction temperature.
    b. Refrigerant discharge temperature.
    c. Outdoor air temperature.
    d. Refrigerant high pressure.
    e. Refrigerant low pressure.
    f. Oil level.

1. Features and Functions:

    a. Self-diagnostics.
    b. Time delay.
    c. Auto-restart.
    d. Fuse protection.
    e. Auto operation mode.
    f. Manual operation mode.
    g. Night setback control.
    h. Power consumption display.
    i. Run test switch.
    j. Equalize run time between multiple similar components.

2. Communication: Network communication with indoor units and other outdoor unit(s).
3. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
4. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

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H. Unit Electrical:

1. Enclosure: Metal suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according ASTM B 117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.7 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor and outdoor units shall include integral controls and connect through a manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer’s proprietary or open control communication between interconnected units. (Open protocol is strongly preferred.)
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
    b. Integration devices shall be connected to local uninterruptible power supply units to provide at least 5 minutes of battery backup operation after a power loss.
    c. Integration shall include control, monitoring, scheduling, and change of value notifications.

4. Operator Interface:

    a. Operators shall interface with system and unit controls through the following:

        1) Operator interfaces integral to controllers.
        2) Owner-furnished PC connected to central controllers.
        3) Web interface through web browser software.

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4) Integration with Building Automation System.

b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:

1) On/off control.
2) Temperature set-point adjustment.

B. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Temperature Units: Fahrenheit.
4. On/Off: Turns indoor unit on or off.
5. Hold: Hold operation settings until hold is released.
6. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
7. Temperature Display: 1-degree increments.
8. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between 45 and 90 degrees F.
9. Relative Humidity Display: 1 percent increments.
10. Relative Humidity Set-Point: Adjustable in 1 percent increments between 5 and 85 percent.
11. Fan Speed Setting: Select between available options furnished with the unit.
12. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
13. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
14. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
15. Occupancy detection.
16. Service Notification Display: "Filter".
17. Service Run Tests: Limit use by service personnel to troubleshoot operation.
18. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
19. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
20. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
21. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

C. Wireless Controllers for Indoor Units:

1. Wireless Communication:

a. Controller communicates to remote-mounted receiver that is wired to indoor units.

1) Include receivers with wireless controllers as required to complete installation.
2) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.

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b. One wireless controller capable of communicating with one or multiple receivers to control one or multiple indoor units as a group.

2. Controller Battery Life: Minimum three years.
3. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
4. Temperature Units: Fahrenheit.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between 45 and 90 degrees F.
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments between 5 and 85 percent.
12. Fan Speed Setting: Select between available options furnished with the unit.
13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter".
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.
19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
21. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

2.8 SYSTEM REFRIGERANT AND OIL

A. Refrigerant: As required by ductless split system manufacturer for system to comply with performance requirements indicated. ASHRAE 34, Class A1 refrigerant classification. R-410a unless indicated otherwise.

B. Oil: As required by ductless split system manufacturer and to comply with performance requirements indicated.

2.9 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in other Division 23 Sections.

B. Divided-Flow Specialty Fittings: Where required by ductless split system manufacturer for proper system operation, ductless split system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.

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PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.

C. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Service Access:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.

B. Equipment Restraint Installation: Install equipment with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Division 23.

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by ductless split system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

E. In rooms without ceilings, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

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F. Provide lateral bracing if needed to limit movement of suspended units.

G. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

H. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03.

I. Attachment: Install hardware for proper attachment to supported equipment.

J. Place grout under equipment supports and make bearing surface smooth.

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.

C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03.

1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Grouting: Place grout under equipment supports and make bearing surface smooth.

D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Division 07. Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved.

B. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.

C. Install piping and tubing in concealed locations unless otherwise indicated except in equipment rooms and service areas.

D. Conform to Division 23 piping specifications.

3.6 ELECTRICAL INSTALLATION

A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.

B. Comply with Division 26 for wiring, grounding, and bonding connections.

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3.7 INSTALLATION OF SYSTEM CONTROL CABLE

A. Conform to Division 23 and 28 requirements.

3.8 IDENTIFICATION

A. Identify system equipment. Comply with requirements for identification specified in Division 23.

3.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage ductless split system manufacturer's service representative to perform manufacturer’s recommended testing and to observe and inspect components, assemblies, and equipment installations, including controls and connections.

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

C. Prepare test and inspection reports.

3.10 STARTUP SERVICE

A. Engage a manufacturer's service representative to perform systems startup service.

1. Service representative shall be an employee or a factory-trained and -authorized service representative of the ductless split system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service. Installer shall correct deficiencies found during startup service for reverification.

C. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include documentation describing each startup check, the result, and any corrective action required.

3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference. All available system operating parameters shall be included in the information submitted.

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3.11 ADJUSTING

A. Adjust equipment and components to function in accordance with manufacturer’s recommendations.

B. Lubricate equipment as recommended by manufacturer.

C. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

D. Set field-adjustable switches and circuit-breaker trip ranges according to ductless split system manufacturer's written instructions, and as indicated.

E. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.12 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer. Include four service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.13 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software. Provide upgrade notice at least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.14 DEMONSTRATION

A. Engage a manufacturer's employed training instructor or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

B. Location: Owner shall provide a suitable on-site location to host classroom training.

C. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

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2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

D. Acceptance: Obtain written acceptance from Owner's representative that training is complete, and requirements indicated have been satisfied.

END OF SECTION 23 81 26

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SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Ducted fan coil units and accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

C. Shop Drawings:

   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of fan coil unit indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Suspended ceiling components.
   2. Structural members to which fan coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:

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a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.

6. Perimeter moldings.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish 1 spare filters for each filter installed.
2. Fan Belts: Furnish 1 spare fan belts for each unit installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

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B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fan coil units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTED FAN COIL UNITS

A. Manufacturers: Subject to compliance with requirements.

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Carrier Corporation; a unit of United Technologies Corp.
2. Engineered Air.
3. ENVIRO-TEC; by Johnson Controls, Inc.
4. Greenheck Fan Corporation.
5. IEC (International Environmental Corporation); LSB Industries.
6. Krueger.
7. Titus.
8. Trane Inc.
9. YORK; a Johnson Controls company.

C. Fan Coil Unit Configurations: Row Face split.

1. Number of Heating Coils: One.
2. Number of Cooling Coils: One.

D. Coil Section Insulation: 1/2-inch- 1-inch- Insert dimension thick, coated foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

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1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Main and Auxiliary Drain Pans: Plastic Stainless steel Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.

G. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel, with powder-coat finish and removable access panel. Floor-mounting units shall have leveling screws.

H. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

I. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

J. MERV Rating: 8 when tested according to ASHRAE 52.2.

1. Washable Foam: 70 percent arrestance and MERV 3.
2. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV 5.
3. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.

K. Hydronic Coils: Copper tube with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

1. Standards:

a. ASTM B 117 for salt spray.
b. ASTM D 2794 for minimum impact resistance of 100 in-lb
c. ASTM D-3359 for cross hatch adhesion of 5B.

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2. Application: Immersion Spray.
3. Thickness: 1 mil Insert measurement.
4. Gloss: Minimum gloss of 50 gloss units on a single angle 60 degree meter.
5. UV Protection: Spray applied topcoat.

L. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

M. Factory, Hydronic Piping Package: ASTM B 88, Type L ASTM B 88, Type M copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. Three-way, modulating control valve for chilled-water coil.
2. Three-way, modulating control valve for heating coil.
3. Hose Kits: Minimum 400-psig working pressure and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.

    a. Length: 24 inches 36 inches Insert dimension.
    b. Minimum Diameter: Equal to fan coil unit connection size.

4. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
5. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
6. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg F; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.
7. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
8. Wrought-Copper Unions: ASME B16.22.

N. Remote condensing units are specified in Section 236200 "Packaged Compressor and Condenser Units."

O. Control devices and operational sequence are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

P. Basic Unit Controls:

1. Control voltage transformer.
2. Wall-mounting thermostat with the following features.

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a. Heat-cool-off switch.
b. Fan on-auto switch.
c. Fan-speed switch.
d. Manual or Automatic changeover.
e. Adjustable deadband.
f. Concealed or Exposed set point.
g. Concealed or Exposed indication.
h. Degree F indication.

3. Unit-mounted humidistat.

a. Concealed or Exposed set point.
b. Concealed or Exposed indication.

4. Wall-mounting temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.

a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

Q. DDC Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied-Period-Override Operation: Two Insert number hours.
3. Unit Supply-Air Fan Operation:

a. Occupied Periods: Fan runs continuously.
b. Unoccupied Periods: Fan cycles to maintain room setback temperature.

4. Hydronic-Cooling-Coil Operation:

a. Occupied Periods: Open Modulate control valve to maintain room temperature.
b. Unoccupied Periods: Close control valve.

5. Supplemental Heating-Coil Operation:

a. Occupied Periods: Open control valve Modulate control valve Energize heating coil to provide heating if room temperature falls below thermostat set point.
b. Unoccupied Periods: Start fan and open control valve modulate control valve energize heating coil if room temperature falls below setback temperature.

6. Controller shall have volatile-memory backup.

R. Interface with DDC System for HVAC Requirements:

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1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide BACnet or LonWorks interface for central DDC system for HVAC workstation for the following functions:

    a. Adjust set points.
    b. Fan coil unit start, stop, and operating status.
    c. Data inquiry, including supply- and room-air temperature and humidity.
    d. Occupied and unoccupied schedules.

S. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

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

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

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1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

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3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 238219

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SECTION 23 82 39.13 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. DDC: Direct Digital Control.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product.

    1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

2. Shop Drawings:

    1. Include plans, elevations, sections, and details.
    2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
    3. Include location and size of each field connection.
    4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
    5. Indicate location and arrangement of piping valves and specialties.
    6. Indicate location and arrangement of integral controls.
    7. Wiring Diagrams: Power, signal, and control wiring.

1.4 Informational Submittals:

A. Field quality-control reports.

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1.5 Closeout Submittals:

1. Operation and Maintenance Data: For cabinet unit heaters 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. Cabinet Unit-Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. Where a specific manufacturer is listed in the Drawings, this shall be considered the Basis-of-Design.

1. Carrier Corporation.
2. Krueger
3. Modine
4. QMark; Marley Engineered Products.
5. Sterling.
6. Trane.
7. Vulcan.
8. York, a Johnson Controls company.

2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in vertical or horizontal discharge configuration as indicated with adjustable discharge louvers.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1.

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

2.4 CABINETS

A. Material: Steel with baked-enamel with manufacturer’s custom paint, in color selected by Architect.

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1. Recessed Flanges: Steel, finished to match cabinet.
2. Control Access Door: Key operated.

2.5 COILS

A. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 200 deg F. Include manual air vent and drain.

2.6 FAN AND MOTOR

A. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.

B. All motors shall be capable of operating in high static conditions.

C. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 “Common Motor Requirements for HVAC Equipment.”

D. Wiring Terminations: Connect motor to chassis wiring with plug connection.

2.7 CONTROLS

A. Basic Unit Controls:

1. Control voltage transformer.

2. Unit-mounted thermostat with the following features:

    a. Heat-off switch.
    b. Fan on-auto switch.
    c. Manual fan-speed switch
    d. Adjustable deadband.
    e. Concealed set point.
    f. Concealed indication.
    g. Deg F indication.

3. Unit-mounted temperature sensor.
4. Unoccupied period override push button.
5. Data entry and access port.

    a. Input data includes room temperature and occupied and unoccupied periods.
    b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.

B. Electrical Connection: Factory-wired motors and controls for a single field connection.

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2.8 Filters

A. Minimum Efficiency Reporting Value and Average Arrestance. According to AHSRAE 52.2.

B. Material: 1” throwaway filter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

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

3.2 INSTALLATION

A. Install cabinet unit heaters to comply with NFPA 90A.

B. Install new filters in each cabinet unit heater within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Division 26. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect piping to cabinet unit heater’s factory, hot-water piping package. Install the piping package if shipped loose.

C. Install piping adjacent to machine to allow service and maintenance.

D. Comply with safety requirements in UL 1995.

E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 “Hydronic Piping” and Section 232116 “Hydronic Piping Specialties.”

F. Ground equipment according to Division 26.

G. Connect wiring according to Division 26.

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3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

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

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION 23 82 39.13

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SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This section includes the following:

1. Electrical equipment coordination and installation.
2. Grout.
3. Common electrical installation requirements.
4. Typical device mounting heights.
5. Cutting and patching for electrical construction.

B. The work under the contract includes furnishing all materials and components shown on the drawings and listed in the specifications for the installation and operation of complete electrical systems.

C. All wiring associated with Division 26 scope of work, with the exception of low voltage lighting control wiring above accessible ceilings, shall be installed in conduit. Any other use of open-to-air wiring will not be permitted.

1.3 QUALITY ASSURANCE

A. 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 used.

B. Comply with NFPA 70.

C. Include in the Work, as a part of the Bid Proposal, labor, materials, services, apparatus, drawings (in addition to the Contract Documents) as required to complete the intended work.

D. Work for the Project must be performed in accordance with Federal, State and Local Laws, Ordinances, Codes, Rules and Regulations, pertaining to the Work which are hereby made a part of the Contract Documents by reference, the same as if repeated herein in their entirety. Where Contract Documents exceed these requirements, the Contract Documents shall govern. In no case shall Work be installed contrary to or below the minimum legal standards.

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 the 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, wire-ways and cable trays 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. Refer to Division 08 Section “Access Doors and Frames”.

D. Coordinate selection and application of firestopping. Refer to Division 07 Section "Firestopping."

1.5 COMMISSIONING

A. Commissioning of components, equipment and/or system specified in this division is part of the construction process. Project closeout is dependent on successful completion of all commissioning procedures, documentation and issue closure. See Section 01 91 13 for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. All electrical systems shall be fully-rated. Series rated systems are not acceptable.

B. All materials and components shall conform with the Underwriters Laboratories Standards when such standards have been established for the particular materials to be furnished under the contract.

2.2 ADHESIVES AND SEALANTS

A. Adhesives - General: Do not use adhesives that contain urea formaldehyde.

B. VOC Limits for Installation Adhesives, Glues, and Sealants used on the Interior of the Building: Use installation adhesives that comply with SCAQMD Rule 1168 limits for VOC content, calculated in accordance with Rule 1168, less water and exempt compounds:

1. Wood glues: 30 g/L.
2. Contact adhesive: 250 g/L.

3. Dry wall and panel adhesives: 50 g/L.
4. Multipurpose construction adhesives: 70 g/L.
5. PVC welding: 510 g/L.
6. CPVC welding: 490 g/L.
7. ABS welding: 325 g/L.
8. Plastic cement welding: 250 g/L.
9. Adhesive primer for plastic: 550 g/L.
10. Special purpose contact adhesive: 250 g/L.
11. Adhesives, adhesive bonding primers, applied to substrates not listed above. If an adhesive is used to bond dissimilar substrates together, the adhesive with the highest VOC content shall be allowed.

    a. Metal to metal: 30 g/L.
    b. Plastic foams: 50 g/L.
    c. Porous material (except wood): 50 g/L.
    d. Wood: 30 g/L.
    e. Fiberglass: 80 g/L.

12. Aerosol adhesives: Comply with GreenSeal GS-36 – Standard for Commercial Adhesives, VOC content by weight, minus water.

    a. General purpose mist spray: 65 percent.
    b. General purpose web spray: 55 percent.
    c. Special purpose aerosol adhesives, all types: 70 percent.

13. Sealants and sealant primers:

    a. Sealants: 250 g/L.
    b. Sealant primers, non-porous substrates: 250 g/L.
    c. Sealant primers, porous substrates: 775 g/L.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, non-corrosive, non-staining, 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 ELECTRICAL PENETRATIONS

A. Electrical penetrations occurs when raceways and cables penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Cut sleeves to length for mounting 2 inches extending out of both surfaces of walls.

E. Extend sleeves installed in floors 2 inches above finished floor level.

F. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Comply with requirements in Division 7 Section "Firestopping."

G. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

3.3 ACCESS DOORS AND FRAMES

A. Refer to Division 08 Section “Access Doors and Frames” for additional information.

B. Provide access doors and frames as required for all Division 26 components requiring access, maintenance, etc.

3.4 TYPICAL MOUNTING HEIGHTS

A. Devices shall be installed at the mounting heights indicated below unless otherwise noted on the Contract Documents or as required to accommodate equipment, casework or where in conflict with wall treatment at the installation locations. Notify A/E about devices that will be in conflict with wall components (white boards, flat panels, screens, etc.) prior to rough-in for clarification of device location. Refer to the Architectural elevations and details for additional

information on device placement. All heights shall be measured from finished floor unless noted otherwise.

1. Electrical receptacles: +1'-6" to center of device box.
2. Electrical receptacles at counters: +0'-4" above top of backsplash to center of device box.
3. Miscellaneous controls for screens, shades, etc.: +3'-10" to center of device box.
4. Light switches: +3'-10" to center of device box.
5. Dimmer switches: +3'-10" to center of device box.
6. Other lighting control stations: +3'-10" to center of device box.
7. Enclosed switches and motor controllers: +6'-0" top of equipment shall be utilized as a typical mounting height, however, is dependent upon size of equipment. The center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, shall not be higher than +6'-7" above the floor or working platform.
8. Electrical panels: The center of the grip of the top most switch or circuit breaker, when in its highest position, shall not be higher than +6'-7" above the floor or working platform.

3.5 CUTTING AND PATCHING

A. Refer to Division 2 for general cutting and patching requirements and procedures.

B. Cut, channel, chase and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

C. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.6 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 "Firestopping."

3.7 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 26 05 00

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Sections include the following:

1. Division 26 Section "Identification for Electrical Systems" for color-coding and other identification requirements.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Contractor with qualifications and minimum ten (10) years experience in installation, splicing and testing of low voltage power conductors may be considered at discretion of Architect/Engineer, as acceptable agency.

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. Comply with NFPA 70.

D. All products shall be UL listed and labeled.

1.5 COMMISSIONING

A. Commissioning of components, equipment and/or system specified in this division is part of the construction process. Project closeout is dependent on successful completion of all

commissioning procedures, documentation and issue closure. See Section 01 91 13 for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

1. Encore Wire Corporation.
2. General Cable Technologies Corporation.
3. Southwire Company.

B. Conductors:

1. Type THHN/THWN-2: UL Listed; NEMA WC70; VW-1; Solid, uncoated copper conductors per ASTM-B3; stranded, uncoated copper conductors per ASTM-B3, ASTM-B787, and ASTM-B8; ROHS compliant; 600-volt rated; color-coded PVC insulation; rated for use in wet or dry locations at temperatures not to exceed 90 deg C.
2. Type XHHW-2: UL listed, NEMA WC70; VW-1; stranded, uncoated copper conductors per ASTM-B3, ASTM B787, and ASTM-B8; ROHS compliant; 600-volt rated; color-coded cross-linked polyethylene insulation; rated for use in wet or dry locations at temperatures not to exceed 90 deg. C.

2.2 CONNECTORS AND SPLICES

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

1. Hubbell Power Systems, Inc.
2. O-Z/Gedney; EGS Electrical Group LLC.
3. 3M; Electrical Products Division.
4. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper, stranded.

B. Branch Circuits:

1. Sizes #10 AWG and smaller: Copper, solid or stranded, but shall be consistent throughout the entire project. Do not mix the use of solid and stranded.
2. Sizes #8 AWG and larger: Copper, stranded.

C. The minimum conductor size shall be #12 AWG.

D. Voltage Drop: Branch circuit conductors shall be sized for a maximum voltage drop of 3 percent to comply with the requirements of ASHRAE Standard 90.1-2007. The following are minimum allowable conductor sizes based on circuit length. The circuit length shall be measured from the branch panelboard to the furthest device in that circuit. The phase and neutral conductors shall be sized as indicated the entire length of that circuit unless a larger size conductor is indicated on the drawings.

1. Conductor sizes for 20A/1-Phase/120V circuits shall be as follows unless noted otherwise:

a. Circuit length of 0 to 95 feet: #12 AWG.
b. Circuit length of 96 to 150 feet: #10 AWG.
c. Circuit length of 151 to 235 feet: #8 AWG.
d. Circuit length 236 to 380 feet: #6 AWG.

2. Conductor sizes for 20A/1-Phase/277V circuits shall be as follows unless noted otherwise:

a. Circuit length of 0 to 200 feet: #12 AWG.
b. Circuit length of 201 to 350 feet: #10 AWG.
c. Circuit length 351 to 550 feet: #8 AWG.
d. Circuit length 551 to 850 feet: #6 AWG.

3.2 CONDUCTOR INSULATION AND WIRING METHODS

A. Feeders:

1. General use: Type THHN/THWN-2, single conductors in raceway.
2. Underground or below slab: Type XHHW-2, single conductors in raceway.
3. Fire pump ATS feeders (normal and emergency): Type XHHW-2 underground, encased in concrete and single conductors in raceway.

B. Branch Circuits:

1. General use: Type THHN/THWN-2, single conductors in raceway.
2. Underground or below slab: Type XHHW-2, single conductors in raceway

C. Control Circuits, Lighting Control Device Wiring, and Other Division 26 Low Voltage Wiring: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. All cables and conductors shall be installed in conduit. The use of exposed (open) wiring will not be permitted. This shall include all lighting control wiring for occupancy sensors, 0-10V control, etc.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

D. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

1. Colors shall be continuous through the insulation from end to end. Field marking is not acceptable.

E. Each branch circuit shall be provided with a dedicated, 100 percent neutral conductor. Sharing of the neutral conductor between multiple circuits will not be allowed. Each neutral shall be clearly identified with its associated phase conductor.

F. A single raceway shall be limited to a maximum of six current carrying conductors.

G. Each branch circuit conduit shall contain a separate green equipment grounding conductor sized per NEC.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

B. Make splices 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 inches of slack.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test feeder conductors for compliance with requirements.

a. Megger test for insulation integrity.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

END OF SECTION 26 05 19

SECTION 26 05 20 MC AND AC CABLE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions, Amendments to the General Conditions and Division-1 Specification Sections, apply to this and other Sections of Division-26.

B. Attention is called to specific requirements in these Division-26 Sections:

1. Basic Electrical Materials and Methods
2. Raceways
3. Wires and Cables
4. Grounding

1.2 SUMMARY

A. This Section includes Metal-Clad Cable (MC) and Armored Cable (AC) assemblies of insulated conductors enclosed in a flexible metal sheath or enclosure for power, lighting, signal, control and related systems rated 600 volts and less.

1.3 SUBMITTALS

A. Submit manufacturer's data as required in Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables."

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following code:

1. NFPA 70: "National Electrical Code."
2. UL Compliance: Provide components which are listed and labeled by UL under the following standards.

a.	UL Std.	4	Armored Cable.
b.	UL Std.	83	Thermoplastic-Insulated Wires and Cables.
c.	UL Std.	486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors.
d.	UL Std.	1569	Aluminum Armored Cable.

3. NEMA/ICEA Compliance: Provide components which comply with the following standards:

a. WC-5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

1.5 DELIVERY, STORAGE AND HANDLING

A. Submit manufacturer's data as required in Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables."

1.6 SEQUENCING AND SCHEDULING

A. Coordinate with other work, including walls and ceiling installation, as necessary to interface installation of cable with such work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. AFC/Nortek.
2. Alflex Corp.
3. Cablec.
4. General Cable Co.
5. Southwire Company.

2.2 MATERIALS, GENERAL

A. All conductors shall be copper.

B. Insulation shall be either thermoplastic or thermosetting and shall be rated for 75 degrees or 90 degrees C.

C. Grounding conductors required on the drawings or required by the NEC shall have green color insulation and shall be copper and shall be sized in accordance with the NEC.

D. Refer to the Section "Low Voltage Electrical Power Conductors and Cables" for additional requirements.

2.3 METAL-CLAD CABLE (MC)

A. MC cable shall be installed in accordance with the NEC. MC cable shall be understood to mean type MC or type CS (copper sheath) or ALS (aluminum sheath).

B. MC cable may be used with conductor size #12 through #6 only, and no larger than a 50A

OCP device.

2.4 ARMORED CABLE (AC)

A. AC cable shall be installed in accordance with NEC.

B. AC cable may be used with conductor sizes 12 through #1 AWG only.

C. In addition to the circuit conductors, AC cable shall have an internal bonding strip of copper or aluminum in intimate contact with the armor for its entire length. This bonding strip shall be bent back on the sheath at each termination. This bonding strip shall be included in all armored cable and is not shown on the drawings.

D. Where a ground conductor is shown on the drawings or where it is required by the NEC, such ground conductor shall be in addition to the bonding strip defined in the paragraph above.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. MC and AC cable shall be permitted wherever EMT conduit and wiring are permitted for branch circuit work; it shall be permitted in dry locations only, concealed in suspended ceilings or wall and not subject to damage or otherwise prohibited by code.

B. Feeders: MC and AC cables may not be used as feeders no matter the size.

C. Underground: MC and AC cable shall not used underground.

D. Concrete: MC and AC cable shall not be used embedded in concrete.

E. Assembly Areas: AC cable shall not be used in assembly areas as defined in NEC.

F. MC or AC cables shall not be installed horizontally in any type of wall.

G. Electrical, Mechanical, plumbing, and general utility Space: MC and AC cable shall be permitted but not below 9’-0” AFF.

H. MC or AC cables shall not be used where exposed in any area that is finished with painted surfaces and architectural ceilings.

I. MC or AC cables shall not be used for circuit homeruns nor circuits that are 100’ or longer.

3.2 INSTALLATION OF TYPE AC AND MC

A. AC cable shall be secured by approved straps, staples or fittings at intervals not exceeding 4-1/2 feet and within 12 inches from boxes or fittings, except when the cable is fished. MC cable shall be supported at intervals not exceeding 6 feet. Cable shall not be supported by draping on suspended ceiling tiles, pipes, ducts, etc. Cable for branch circuits with #12 or #10 AWG conductors may be secured by nylon ties except where the support may slip (such as along ceiling support wires). Cables for lighting circuit branch wiring may be supported from the ceiling support wires using spring steel clips listed for such application.

B. All bends shall be made so that the type AC cable will not be injured, and the radius of the curve of the inner edge of any bend shall not be less than five (5) times the diameter of the cable.

C. Where change is made from type AC or MC cable to raceway wiring methods or to other cable, or a box shall be installed.

D. At all points where the armor of AC and MC cable terminates, a fitting shall be provided to protect wires from abrasion and, in addition, an approved insulating bushing shall be provided between the conductors and the armor. The connector or clamp by which the cable is fastened to boxes or cabinets shall be of such design that the insulating bushing will be visible for inspection.

END OF SECTION 26 05 20

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment. Also includes common ground bonding with lightning protection systems.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:

1. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.

    a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
    b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. 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.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Comply with Division 26 Section “Low Voltage Electrical Power Conductors and Cables.”

B. Bare Copper Conductors:

1. Solid conductors: ASTM B 3.
2. Stranded conductors: ASTM B 8.
3. Tinned conductors: ASTM B 33.
4. Bonding cable: 28 kcmil, 14 strands of No. 17 AWG conductor and 1/4 inches in diameter.
5. Bonding conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned bonding jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Rectangular bars of annealed copper, 1/4-inch thick X 4-inch high X 24-inch long with holes, unless otherwise indicated; with insulators.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, 3/4 inch in diameter by 10 feet long.

2.4 GROUNDING OF SPECIAL CABINETS

A. At all flammable materials storage cabinets, solvent storage cabinets, corrosive storage cabinets and gas safety cabinets, provide a (minimum) #12 AWG copper, insulated green grounding conductor from the equipment grounding conductor of the nearest available 120 volt circuit.

B. Extend cabinet bonding conductor from the nearest circuit outlet box via 3/4-inch conduit concealed in wall and stubbed out behind the respective cabinet. Conduit shall be converted to flexible metal conduit where exposed, and shall terminate with a UL listed bushing. Where indicated on the drawings, provide a flush wall box with cover plate (with grommeted hole, 3/4-inch diameter) and extend bonding conductor from wall box to equipment terminal.

C. Bonding conductor shall be secured to bonding terminal of the cabinet. If the cabinet is not equipped with a bonding terminal, provide a UL listed screw terminal and permanently secure it

to the metallic cabinet with a screw, lockwasher and bolt. Self-tapping sheet metal screws will not be accepted as the means of attachment.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Comply with Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 3/0 AWG minimum.

1. Bury at least 24 inches below grade.

C. Grounding Bus: Install in electrical rooms, telecommunication rooms, systems rooms, fire pump room and elsewhere as indicated.

1. Install bus on insulated spacers 1 inch minimum from wall 6 inches above finished floor, unless otherwise indicated.
2. All connections at each ground bus shall be labeled to identify source.

D. Conductor Terminations and Connections:

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 structural steel: Welded connectors.
4. Water service: Bolted connectors.
5. Fire protection service: Bolted connectors.
6. Natural gas service: Bolted connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Hand-Holes: Install a driven ground rod in hand-hole, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before hand-hole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into hand-hole through a waterproof sleeve in hand-hole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete.

C. Utility Transformers: Coordinate grounding and pad requirements at utility transformers with utility. Furnish and install as directed by Utility.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors for all electrical distribution, in addition to those required by NFPA 70 and as follows:

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.

B. Metal Poles Supporting Outdoor Lighting Fixtures: Install as per pole mounting detail shown on drawing.

3.4 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 6 inches 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.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to equipment mounted on vibration isolation hangers and supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal water service pipe: Provide bonding as per NEC 250, 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, using a bolted clamp connector or by bolting a lug-type

connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water meter piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each above ground portion of gas piping system downstream from equipment shutoff valve.

F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

G. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 3/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building foundation.

H. Building Footing Ground: Provide per NEC 250.

I. Standby Emergency Generator Grounding Requirements: Provide four (4) ground rods, one at each corner of the generator set. Provide bare No. 3/0 AWG conductors underground interconnecting these ground rods forming a ring around the generator. Bond to the generator with No. 3/0 AWG from two (2) opposite corners. Also, bond neutral and ground at generator to form a separately derived system.

J. Pull Boxes:

1. Provide grounding type bushings on conduit entrance into pull boxes. The equipment grounding conductor shall be bonded to the box via threaded, locking type ground bushing at the conduit entrance.

K. Junction Boxes and Device Boxes:

1. Bond junction boxes and device boxes to the equipment grounding conductor within the branch circuit serving the box via an approved method.

L. Panelboards:

1. Bond panelboards to the equipment grounding conductor within the feeder conduit by a threaded grounding type insulated bushing at the conduit entrance into the tub. The equipment grounding conductor shall continue from the bushing to the panelboard ground bus and be bonded.
2. Bond the equipment grounding buses of normal and essential branch circuit panelboards serving the same patient care areas as required by NEC 517. Bond with a minimum #10 awg insulated continuous copper conductor routed in conduit.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Perform tests by fall-of-potential method according to IEEE 81 and submit test.

B. Report measured ground resistances that exceed the following values:

1. Power and lighting equipment or system: 5 ohms.
2. Power distribution units or panelboards serving electronic equipment: 3 ohms.
3. Pad-mounted equipment: 5 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

D. Documentation of the Ground and Neutral Bond Jumper: Provide a digital photograph documenting the location of each ground to neutral bond at each separately derived system. Shall include photograph of bonding location and a second photograph confirming the system is not bonded at another location. Label each photograph accordingly. For example, provide a photograph of the bond within transformer secondary and second photograph confirming distribution panel is not bonded. Include these in the Operation and Maintenance Manuals.

END OF SECTION 26 05 26

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. GRC: Galvanized rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

C. Comply with IBC and UBC.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.7 COMMISSIONING

A. Commissioning of components, equipment and/or system specified in this division is part of the construction process. Project closeout is dependent on successful completion of all commissioning procedures, documentation and issue closure. See Section 01 91 13 for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

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

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.

2. Metallic coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Painted coatings: Manufacturer's standard painted coating applied according to MFMA-4.
5. Channel dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-expansion anchors: Insert-wedge-type, stainless steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

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

1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

2. Concrete inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for attachment to steel structural elements: MSS SP-58, type suitable for attached structural element.
4. Through bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle bolts: All-steel springhead type.
6. Hanger rods: Threaded steel.

G. Install no anchors in the underside of concrete joists or beams. All anchors must be set horizontally as near as possible to the neutral axis of the structural member. Drill and set anchors in beams.

H. Powder driven anchors or studs will not be allowed.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 5 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and GRC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter. Support conduit within 10 inches from box and bend, maximum 10 feet apart and minimum of one support for

conduit length. The maximum support for conduits 1 inch and smaller shall be 5 feet, and for conduits larger than 1 inch shall be 8 feet.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

D. Single Conduits 1-1/2-Inch and Smaller: Conduit clamps for supporting single conduits shall be with bolt type clamps. The use of spring type clamps will not be permitted. This requirement shall apply to conduits above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and GRC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To wood: Fasten with lag screws or through bolts.
2. To new concrete: Bolt to concrete inserts.
3. To masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To existing concrete: Expansion anchor fasteners.
5. To steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
6. To light steel: Sheet metal screws.
7. Items mounted on hollow walls and non-structural building surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Powder-actuated driven anchors or studs will not be allowed.

F. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 5 Section "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.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit. Anchors shall be a minimum of 10 bolt diameters from edge of the base. Chamfer concrete pad 3/4 inch.

1. All floor mounted electrical equipment installed in mechanical rooms, electrical rooms, boiler rooms, penthouse, below grade spaces and exterior to the building shall be furnished with a housekeeping pad.
2. Interior pads shall be Class 2 concrete, shall extend 4 inches beyond all accessible sides of the equipment footprint, shall be 4 inches high and shall have 3/4 inch chamfered edges. Pads shall be doweled to the floor in at least four places (each conduit penetration may be counted for one dowel). Pads shall have heavy mesh reinforcing and have any existing floor coating re-extended to the lower edge of the chamfer. Pads sized or detailed on the Drawings and/or in job scope, shall be constructed as indicated or as required by the application.

B. Use 4000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Refer to Division 26 Section “Identification for Electrical Systems” for additional painting requirements.

B. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils. Retain first paragraph below if a Division 9 painting Section is in Project Manual.

C. Touchup: Comply with requirements in Division 9 painting sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

D. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

SECTION 26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
2. Surface raceway.
3. Conduit sleeve and firestop.
4. Core drill for electrical work.

B. Related Section includes the following:

1. Division 26 Section "Underground Utility Structures for Electrical Systems."

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. GRC: Galvanized rigid metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquid-tight flexible metal conduit.

E. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For raceways, wireways, fittings, enclosures, and cabinets.

B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

C. Source quality-control test reports.

D. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."

2. Dimensioned outline drawings of equipment unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70, 79.

C. Products shall be UL listed and labeled.

D. Comply with ANSI C2.

1.6 COMMISSIONING

A. Commissioning of components, equipment and/or system specified in this division is part of the construction process. Project closeout is dependent on successful completion of all commissioning procedures, documentation and issue closure. See Section 01 91 13 for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

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

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Maverick Tube Corporation.
3. O-Z Gedney; a unit of General Signal.
4. Wheatland Tube Company.

B. Galvanized Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. EMT: ANSI C80.3.

E. LFMC: Flexible steel conduit with PVC jacket and UL label.

F. Fittings for Conduit (Including all Types and Flexible and Liquid-tight): NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Fittings for EMT: Steel set screw, insulated throat, concrete tight couplings and connectors. Other type fittings will not be acceptable.
2. Fittings for rigid steel and intermediate steel conduit: Threaded.
3. Flexible conduit connectors: UL listed for grounding, squeeze type, malleable iron with insulated throat and one or two screw types. Set screw type, die-cast, or screw-in type will not be allowed.
4. Liquid-tight fittings: UL listed for grounding, ferrule, and sleeve type with insulated throat.

G. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

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

1. CANTEX Inc.
2. Lamson & Sessions; Carlon Electrical Products.
3. Manhattan/CDT/Cole-Flex.
4. RACO; a Hubbell Company.
5. Thomas & Betts Corporation.

B. RNC: NEMA TC 2, Heavy wall type EPC-40-PVC, unless otherwise indicated.

C. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

2.3 METAL WIREWAYS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

1. Indoor, JIC type, minimum 16 gage, 14 gage for 6” X 6” or larger, finish with gray enamel finish.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wire-way Covers: As indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. Hoffman.
3. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
4. O-Z/Gedney; a unit of General Signal.
5. RACO; a Hubbell Company.
6. Spring City Electrical Manufacturing Company.
7. Thomas & Betts Corporation.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1, minimum 4" X 4" X 2-1/8" deep. Provide with single gang plaster ring unless two gang plaster ring is specifically noted elsewhere to be provided.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover. Minimum 4" X 4" X 2-1/8" deep. Provide with single gang plaster ring unless two gang plaster ring is specifically noted elsewhere to be provided.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1 gasketed cover.

F. Stainless Steel Boxes: NEMA 4X; Grade 316L.

G. Device rough-in boxes shall be securely and rigidly attached between two structural members and supported plumb, level and true to the building lines using one of the following:

1. Extension plate bracket: Allow outlet boxes 12" or 18" offset from either metal stud track or a stud. Allow 4" or 4-11/16" outlet boxes, 2-1/8" deep.
2. Device box brackets attaching to only one metal stud will not be allowed.

PART 3 - EXECUTION

3.1 RACEWAY AND BOX APPLICATION

A. Outdoors: Apply raceway and box products as specified below, unless otherwise indicated:

1. Exposed conduit: GRC.
2. Concealed conduit, above ground: GRC.
3. Underground conduit:

    a. Utility transformer secondary building entrances: PVC Schedule 80.
    b. Generator service entrance: PVC Schedule 40 in a concrete encased duct bank.
    c. Fire pump ATS service: PVC Schedule 40 in a concrete encased duct bank.
    d. Other: PVC Schedule 80, direct bury conduit, unless noted otherwise.

4. Connection to vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment): LFMC.
5. Boxes and enclosures, above ground: NEMA 250, Type 4X, stainless steel.

B. Indoors: Apply raceway and box products as specified herein, unless otherwise indicated:

1. Exposed in mechanical room: IMC, unless GRC is required as directed by any of the categories below.
2. Below grade: GRC.
3. Branch circuit: EMT. Where branch circuits fall into one of the other categories listed, that category's specification shall be followed. For example, branch circuits in a concrete wall shall utilize type GRC.
4. Concrete wall/column: GRC.
5. Panel or equipment feeder:

    a. Less than 100 amps: EMT unless IMC or GRC is required as directed by any of the other categories.
    b. 100 amps and larger: IMC unless GRC is required as directed by any of the other categories.

6. Connection to vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment): LFMC.
7. Damp or wet location: GRC.
8. Fire pump ATS service: PVC Schedule 40 under-slab in a concrete encased duct bank.
9. Boxes and enclosures: Rated for the environmental conditions at the installed location.

    a. Dry and clean locations: NEMA 250, Type 1.
    b. Damp or wet locations: NEMA 250, Type 4X, stainless steel.

C. Minimum Raceway Size: 3/4-inch trade size.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. All conductors for every electrical system shall be installed in a raceway.

C. A single raceway shall be limited to a maximum of six current carrying conductors.

D. Separate conduit systems shall be provided for each electrical system category.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical System."

H. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

I. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

J. Conceal conduit within finished walls and ceilings, unless otherwise indicated.

K. Raceways embedded in slabs or below slab inside the building envelope are not permitted unless shown on Contract Documents.

L. RNC Installation:

1. Entire installation shall be watertight.
2. Where exiting or entering a concrete slab, PVC shall be adapted to rigid conduit at least 12 inches prior to entering or exiting.

M. Threaded Conduit Joints Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

N. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including bushing for size No. 6 AWG and larger conductors.

O. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

P. Raceways for Optical Fiber and Communications Cable: Install raceways as follows:

1. 3/4-Inch trade size and smaller: Install raceways in maximum lengths of 50 feet.
2. 1-Inch trade size and larger: Install raceways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes

or terminations at distribution frames or cabinets where necessary to comply with these requirements.

Q. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

R. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, use maximum of 36 inches of LFMC for equipment subject to vibration, noise transmission, or movement; transformers, motors and damp/wet location. Support within 72 inches of light fixture and 36 inches of motor terminals.

S. 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.

T. Conduits Penetrating Roof:

1. One conduit per sleeve. Minimum height of sleeve not less than 8 inches above roof membrane.
2. Provided rain shield on conduit overlapping sleeve a minimum of 2 inches. Secure rain shield to conduit with stainless steel pressure clamps and provide flashing as required.

U. Expansion coupling/fitting shall be installed for conduit passing through building expansion joint. Provide bonding jumper with conduit/pipe clamp to maintain raceway as grounding continuity. The expansion fitting shall be similar to O-Z/Gedney EX Series. Expansion fitting/coupling length and diameter shall be as required for the application.

V. Raceways shall run parallel and perpendicular to the building surface walls or exposed structural members and follow the surface contours to present a neat appearance. This shall apply to exposed structure, accessible ceiling and hard ceiling area of the facility.

W. Junction Boxes: Do not locate junction boxes above hard (gypsum) ceilings.

3.3 DEVICE ROUGH-IN BOX

A. Finish plates shall not span different types of wall finishes either vertically or horizontally. Plates shall cover mortar joints and cut openings completely.

B. Outlet, junction and pull boxes, and their covers shall have corrosion protection suitable for the atmosphere in which they are installed. Provide gaskets for all boxes installed outside and other wet or damp locations (tunnels, crawl spaces, pits, etc.).

C. Outlet boxes shall be protected to prevent entrance of plaster, and debris shall be thoroughly cleaned from the box prior to installation of conductors.

D. Single gang opening outlet boxes shall be mounted with the long axis vertical unless otherwise noted for horizontal mounting. Three or more gang boxes shall be mounted with the long axis horizontal.

E. Finish plates shall be a type designed, intended, and appropriate for the use and location.

F. Provide outlet box with barrier for grouped or ganged light switched where voltage between adjacent switches exceeds 300 volt AC per NEC Article 380.

G. Provide outlet box with barrier and separate conduit feed for switches grouped or ganged where connected to utility power and standby power.

3.4 METAL RACEWAY

A. Metal raceway duct shall be installed level and true to building construction lines such that removable or hinged covers can be operated to be fully accessible.

B. Routing shall be pre-planned by the Contractor to assure right-of-way and accessibility; routing indicated by Contract Documents shall be considered schematic in nature and may require job site alteration to avoid interference.

C. Metal raceway duct shall be adequately supported at not more than 5'-0" intervals. The support accessories shall be of the same manufacturer as metal raceway.

D. Metal raceway duct penetrations of walls shall be unbroken lengths, scaled to the wall opening; dead ends shall be closed with manufactured closures.

E. Metal raceway duct to be installed surface mounted; flush in wall or in floor as indicated by the Contract Documents.

F. Provide approved wall flanges and fully seal all penetrations of fire and smoke rated walls and partitions, cutting and patching as needed.

G. Provide divider to compartment the metal raceway duct as indicated by Contract Documents.

3.5 INSTALLATION OF UNDERGROUND CONDUIT

A. Concrete-Encased Duct Bank: Refer to the requirements in Division 26 Section “Underground Ducts and Raceways for Electrical Systems”.

B. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12

inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

5. Warning Tape: Bury warning tape approximately 12 inches below grade. Align tape along the width and along the centerline of conduit.

3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

END OF SECTION 26 05 33

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes electrical identification requirements.

B. Related Sections include the following:

1. Division 26 Section "Electrical System Fault Analysis, Coordination and Arc Flash Study" for labeling requirements.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.145.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

1.6 COMMISSIONING

A. Commissioning of components, equipment and/or system specified in this division is part of the construction process. Project closeout is dependent on successful completion of all commissioning procedures, documentation and issue closure. See Section 01 91 13 for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Color for Printed Legend:

1. Power circuits:

a. Utility power: Black letters on a white field.
b. Standby power: White letters on a red field.

2. Legend: Indicate system or service and voltage, if applicable.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.2 CONDUCTOR IDENTIFICATION MATERIALS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, detectable-type, continuous-printed, polyethylene tape.

1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

C. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple power source warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace clearance warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 42."

2.5 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. Black letters on a white background for utility power white letters on a red background for standby power. Minimum letter height shall be 3/8 inch.

1. Label shall identify equipment served, source of feed and circuit number.

2.7 DEVICE, RECEPTACLE AND SWITCH LABELS

A. Label shall be self-adhesive vinyl and shall be computer or machine printed. Minimum size shall be 1/4-inch label with 1/8-inch letters.

1. Label background shall be clear or match to device plate.
2. Black lettering.
3. Legend: Indicates panel and circuit number.

B. Special Receptacles:

1. Special purpose receptacles shall include an engraved or embossed legend appropriate for load serviced and labeled as specified in Paragraph A.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum width: 3/16 inch.
2. Tensile strength: 50 pound minimum.
3. Temperature range: Minus 40 to plus 185 deg F (minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

2.9 PAINTING

A. Refer to Division 09 Section “Painting” for product and material requirements for preparing and painting of exposed electrical raceways and boxes.

PART 3 - EXECUTION

3.1 APPLICATION

A. Accessible Raceways, 600 V or Less, for Feeder and Branch Circuits: Identify with preprinted self-adhesive vinyl label based on voltage contained and as follows:

1. 120/208 volt system: Black letters on a white field for normal power and white letters on a red field for emergency power. Shall read as "120/208 VOLTS."
2. 277/480 volt system: Black letters on a white field for normal power and white letters on a red field for emergency power. Shall read as "277/408 VOLTS."

B. Raceways and Junction Boxes for the Fire Alarm System: All conduits associated with the fire alarm system shall be fire alarm EMT conduit with a bright red topcoat. All junction boxes shall be painted to match the red conduit.

C. Conductors:

1. Feeder wires shall be identified with voltage, phase, and destination at each access point. Each phase conductors shall be identified with colored insulation its entire length.
2. Wiring shall be identified with wrap-on wire markers. Wire markers shall be vinyl cloth with factory painted letters and numbers. Number shall indicate associated terminal in starter, panelboard, etc.
3. All transformers, distribution panels, feeders, power sub-feeds to motors, etc., shall be completely phased out as to sequence and rotation and so labeled.
4. Neutral conductors at each panel, junction box, etc., shall be permanently and effectively identified with its branch circuit conductor taped together and labeled with circuit number. The neutral shall have a colored strip that corresponds to the phase color of the non-grounded conductor.

D. Pull and Junction Boxes, Feeder Bus Taps:

1. Identify by stenciling on the boxes, system use, etc. as directed.
2. Covers for pull and junction boxes shall be marked with felt tip pen or other approved permanent marking means, including system type, i.e., lighting, power, emergency, etc.,

panel and circuit number, if applicable designation, etc. Example: Room C703, Panel 1-LN-1, Circuit #12.

E. Device Cover Plates:

1. Receptacle cover plates shall be identified by a clear label with black lettering indicating panel and circuit.
2. Switch cover plates shall be identified by a clear label with black lettering indicating panel and circuit.

F. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, and control wiring.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Apply to exterior of door, cover, or other access.

1. Equipment with multiple power or control sources: Apply to door or cover of equipment including, but not limited to, the following:

a. Power transfer switches.
b. Controls with external control power connections.
c. Emergency power system.

2. Equipment requiring workspace clearance according to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

I. Arc Flash Labeling: Comply with the requirements of Division 26 Section "Electrical System Fault Analysis, Coordination and Arc Flash Study."

J. Instruction Signs:

1. Operating instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
2. Emergency operating instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels on each power and system equipment/panel power equipment. Label shall include device identification and source.

1. Labeling instructions:

a. Indoor equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where 2 lines of text are required, use labels 2 inches high.
b. Outdoor equipment: Engraved, laminated acrylic or melamine label.
c. Elevated components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. Equipment to be labeled:

a. Switchgear.
b. Switchboards.
c. Panelboards, electrical cabinets, and enclosures.
d. Access doors and panels for concealed electrical items.
e. Transformers.
f. Disconnect switches.
g. Enclosed circuit breakers.
h. Variable frequency controllers.
i. Motor starters.
j. Distribution panels.
k. Contactors.
l. Fire-alarm control panel and annunciators.
m. Transfer switches.

3. Equipment schedule:

a. Panelboards shall include correct, typewritten circuit directory cards identifying load served by branch circuit protective devices.
b. Panelboards shall include designation label, voltage, phase, wires, ampere, fed from, short circuit ratings, arc flash hazard level and feeder size on exterior cover of the panel door.

4. Distribution panels shall have labeling for each circuit breaker frame/trip size, including spare and spaces/provisions.
5. Motor controllers and disconnect switches: Label each with engraved plastic label with 1/2-inch high letters securely attached to the exterior of device as follows:

a. Equipment served, voltage, phase and wire.
b. Source of feed and circuit number. For example, “MS-AHU-1 fed from B-HEQDP-1 Circuit #4 located in Room B053”.
c. Feeder size.

6. Panelboards:

a. Provide approximately 5" X 8" frame inside the door with plastic protected typewritten directory card identifying all circuits with Owner's final room number.
b. Engraved plastic label with 1/2-inch high letters on panel cover identifying panel, voltage, phase, wire, ampere source of feed, short circuit rating, arc flash hazard level and feeder size.

7. Switchgear, switchboards and distribution panels:

a. Provide an engraved plastic label with 3/4-inch high letters, securely attached, identifying panel, voltage, phase, wire, ampere, source of feed, short circuit rating, arc flash hazard level and feeder size.
b. Branch devices shall be labeled with engraved plastic label with 3/16-inch high letter securely attached to exterior of device.

8. Transfer switches:

a. Label "Normal" and "Emergency" poles with engraved plastic tags.
b. Label with source designations for both sources.
c. Identify switch, voltage, phase, wire, ampere, short circuit rating, arch flash hazard level and feeder sizes.

L. Emergency Source Sign: Provide a sign complying with the requirements of NEC Article 700 identifying the presence of the on-site emergency power source. Locate in a conspicuous location on the utility source main switchboard near the main breaker. Sign shall read “Standby emergency power source. Diesel emergency generator. Located outdoor west of the facility”.

M. Painting:

1. Refer to Division 09 Section “Painting” for execution requirements related to painting of exposed Division 26 components.
2. Apply field labeling and other identification materials after painting has been completed.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. Accessible Raceway Labeling: Install at a conveniently viewable location. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for feeder and branch-circuit conductors. Colors shall be factory applied and continuous through the insulation from end to end. Field marking is not acceptable.

1. Colors for 208/120-V circuits:

a. Phase A: Black.
b. Phase B: Red.

c. Phase C: Blue.
d. Neutral:

1) Phase A: White with black strip.
2) Phase B: White with red strip.
3) Phase C: White with blue strip.

e. Ground: Green.

2. Colors for 480/277-V circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.
d. Neutral:

1) Phase A: Gray with brown strip.
2) Phase B: Gray with orange strip.
3) Phase C: Gray with yellow strip.

e. Ground: Green.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 12 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

END OF SECTION 26 05 53

SECTION 26 05 73 – ELECTRICAL SYSTEM FAULT ANALYSIS, COORDINATION AND ARC FLASH STUDY

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 requirements and provisions for providing a fault analysis study, arc flash analysis study, and overcurrent protection device coordination study for the entire electrical system including, but not limited to panels, switchgear, generator, transfer switches, mechanical equipment loads, etc.

B. This Section includes computer-based, fault-current, arc flash, and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

C. Series rated protective devices are not permitted unless noted otherwise.

D. Protective devices and equipment requiring coordination will not be approved by Engineer until entire coordination study has been approved.

E. The coordination study shall include devices down to the branch circuit breakers in panelboards.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Submit one line schematic, fault-analysis coordinated study and arc flash analysis in both paper hard copy format and also in computer format (SKM files).

E. Other Action Submittals: The following submittals shall be made prior to the approval process for system protective devices has been completed. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.

3. Coordination-Study Report (TCC Graphs):

a. Coordination-study report shall be submitted in color.

F. Obtain written correspondence from local utility denoting maximum and minimum available fault current at main service. Data shall be submitted.

G. Approved studies and utility correspondence shall be included in O & M Manual. Include color hard copies and computer software files on a CD.

H. Submit sample Arc Flash label (in color) prior to approval.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional Engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

E. Comply with the latest Edition of NFPA 70E.

F. Comply with all applicable OSHA regulations.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Product:

1. SKM Systems Analysis, Inc. The latest available version of this software shall be utilized.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Additional features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

D. Arc Flash Analysis.

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. Devices to be coordinated are indicated on Drawings.

1. Proceed with equipment submittals only after relevant coordination study has been provided and approved.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical distribution system diagram: In hard-copy and electronic-copy formats, showing the following:

a. Circuit-breaker and fuse-current ratings and types.
b. Relays and associated power and current transformer ratings and ratios.
c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
d. Generator kilovolt amperes, size, voltage, and source impedance.
e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.

f. Busway ampacity and impedance.
g. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.
b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve and decrement curves.
e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves to be coordinated for entire system.
h. Manufacturer, frame size, interrupting rating in amperes RMS symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes RMS symmetrical.
k. TCC curve showing branch protective devices coordinated with upstream devices.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes RMS symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Switchgear.
2. Switchboard.
3. Distribution panelboard.
4. Branch circuit panelboard.
5. Disconnect switch.
6. Motor controllers.
7. Automatic transfer switches.
8. Generator.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions. Scenarios shall evaluate utility maximum and minimum values, as well as various main and tie switching combinations along with the various generator combinations at the minimum and maximum utility values.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 242.

1. Transformers:

a. ANSI C57.12.10.
b. ANSI C57.12.22.
c. ANSI C57.12.40.
d. IEEE C57.12.00.
e. IEEE C57.96.

2. Low-voltage circuit breakers: IEEE 1015 and IEEE C37.20.1.
3. Low-voltage fuses: IEEE C37.46.

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium- and high-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. 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.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall 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 shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular format of settings selected for overcurrent protective devices:

a. Device tag.
b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
d. Fuse-current rating and type.
e. Ground-fault relay-pickup and time-delay settings.

2. Coordination curves: Prepared to 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 the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.
b. Voltage and current ratio for curves.
c. Three-phase and single-phase damage points for each transformer.
d. No damage, melting, and clearing curves for fuses.
e. Cable damage curves.
f. Transformer inrush points.
g. Maximum fault-current cutoff point.

3. Coordination curves:

a. Electronic breaker: Coordination curves shall be provided for all devices identifying time separation between subsequent devices.
b. Molded case breaker: Coordination curves shall be provided for the largest device of every different model of breaker within each different panelboard condition identifying time separation between subsequent devices.
c. Coordination of protection devices shall be demonstrated down to breakers in the panelboard.

F. Completed data sheets for setting of overcurrent protective devices.

G. Upon device installation, submit written correspondence noting all protective device adjustments have been performed.

3.5 ARC FLASH STUDY

A. Provide an Arc Flash Hazard Study for all electrical equipment in the electrical distribution system. The intent of the arc flash study is to provide arc flash analysis values for all equipment and subsequently provide arc flash hazard warning labels on all electrical equipment involved in the study.

B. Upon completion of coordination study and fault analysis study, arc flash study shall be performed based upon IEEE Std. 1584, "IEEE Guide for Performing Arc Flash Hazard Calculations."

C. The study shall be computer calculated with scenarios utilizing both minimum and maximum fault current values from the local utility. Scenarios shall also evaluate the various main and tie switching combinations along with the various generator combinations at the minimum and maximum utility values.

D. Calculations and practices shall be in accordance with applicable NFPA 70E, OSHA 29-CFR, Part 1910, and IEEE 1584 standards.

E. The following values shall be calculated and submitted to the Engineer in a summary sheet along with pertinent data and characteristics pertaining to the evaluated equipment.

1. Flash hazard protection boundary.
2. Limited approach boundary.
3. Restricted boundary.
4. Prohibited boundary.
5. Incident energy level.
6. Required Personal Protective Equipment (PPE) Class.
7. Type of fire rated clothing.

F. All equipment including, but not limited to, the following shall be included in the study.

1. Switchgear.
2. Switchboard.
3. Transformers.
4. Panelboards.
5. Variable frequency controllers.
6. All mechanical motor controllers $\geq$ 10 hp.
7. Disconnect switches and enclosed circuit breakers.
8. Automatic transfer switches.
9. Generator.

G. Produce and provide an arc flash warning label denoting items in Paragraph E.1 through E.7 above for all electrical pieces of equipment.

1. Label shall be printed in color and with an adhesive backing.

2. Label shall also include the following information on the label:

    a. Equipment Name.
    b. Bus Voltage.
    c. "WARNING."
    d. "ARC FLASH & SHOCK HAZARD."
    e. "Appropriate PPE Required."

H. Electrical Contractor shall be responsible to receive labels and install labels on all equipment.

1. Label shall be installed on front of unit in a conspicuous location below equipment nameplate(s).

END OF SECTION 26 05 73

SECTION 26 09 23 - LIGHTING CONTROL DEVICES

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. Section Includes:

1. Time Clock.
2. Photoelectric switches.
3. Indoor occupancy sensors.
4. Lighting contactors.
5. Digital room controllers.
6. Digital wall control stations.

PART 2 - PRODUCTS

2.1 TIME CLOCK

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

1. Intermatic, Inc.
2. Paragon Time Controls
3. Emersion Network Power; ASCO Lighting Control
4. NSi Industries LLC; TORK Products.

B. Electronic Time Clock: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: single pole, single throw (SPST) or as indicated on the drawings.
3. Contact Rating: 20-A ballast load, 120-/240-V ac. Provide inductive load rated contact where shown on drawings to control motor loads.
4. Programs: Minimum, two on-off set points on a 24-hour schedule, allowing different set points for each day of the week**.**
5. Automatic daylight savings time changeover.
6. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

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

1. Intermatic, Inc.
2. NSi Industries LLC; TORK Products.
3. Leviton
4. Sunrise Technologies

B. Description: Solid state, with dry contact rated for 1800-VA, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range**,** and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.3 INDOOR OCCUPANCY SENSORS

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

1. Cooper Industries, Inc.; Greengate
2. Hubbell Building Automation, Inc.
3. Lutron Electronics Co., Inc.
4. Watt Stopper.
5. ***Acuity Controls.***

B. Devices Types: Devices located in stairwells shall be ultrasonic type. All other locations shall be dual-technology (PIR and Ultrasonic) type, unless otherwise noted on drawings or in this specification.

C. General Description: Refer to drawings for type, mounting, integration, etc. and provide accordingly. Wall or ceiling mounting, part of a room controller, relay panel or standalone application. Provide all required relay packs, power packs, accessories, etc. as required to achieve control intent.
1. Operation:
    a. Occupancy senor (auto on/auto off): Turn lights on automatically when covered area is occupied and automatically off when space becomes unoccupied. Shall have a time delay for turning lights off that is adjustable for a range of 1 minute to 30 minutes.
    b. Vacancy sensors (manual on/auto off): Turn lights on when a low voltage wall switch is manually activated and automatically off when space becomes

unoccupied. Shall have a time delay for turning lights off that is adjustable for a range of 1 minute to 30 minutes.

2. Type: All sensors shall be digital, low voltage (Class 2) devices unless specifically noted otherwise.
3. Sensor:
   a. Shall have an internal additional isolated relay with normally open, normally closed and common outputs for use with HVAC control. Sensors utilizing separate components or specially modified units to achieve this function are not acceptable.
   b. Shall not have pop-off covers.
4. Provide with RJ-45 ports for interface with room controller or relay system where applicable.
5. Mounting:
   a. Sensor: Suitable for recessed mounting in any position on a standard outlet box. Surface mount is not acceptable.
   b. Relay: Mounted adjacent to sensor in a dedicated junction box.
6. Adjustments:
   a. Time delay: Adjustable range from 1 minute to 30 minutes, with a maximum of 8 incremental levels.
   b. Sensitivity: Adjustable from low to high sensitivity with a minimum of 3 incremental levels. The use of intelligent, adaptive technology is acceptable.
   c. Adjustment controls shall be concealed out of normal view.
   d. Independent control of PIR and UT technologies.
7. Coverage: The detection coverage of each sensor shall be selected by manufacturer to provide complete coverage of each space based on room type, size, shape and fixed obstructions present within the space. The placement and coverage shall be illustrated on the floor plan submittals as defined in Part 1 of this Section.
8. On/off buttons: Where applicable, provide with single or dual button control as indicated for independent, manual control of loads.
9. Relay/power pack units: Provide quantity of relays and/or power packs as required to meet design intent. Maintain separation of voltage classes and separation of different branches of power (normal, critical, and life-safety) as required by code.
10. Indicator: LED to show when motion is being detected during testing and normal operation of the sensor.
11. The mounting yokes and tabs for attaching wall mounted sensors to the back box shall be of metallic construction. The use of non-metallic or plastic materials will not be permitted.

D. PIR Type: Wall or ceiling mounting, detect occupancy by sensing a combination of heat and movement in area of coverage. Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.

E. Ultrasonic Type: Wall or ceiling mounted, detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage. Detect a person of average size and weight moving not less than 12 inches in either a horizontal or vertical manner at an appropriate speed of 12 inches/s.

F. Dual Technology Type: Wall or ceiling mounting, detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
   1. Sensitivity adjustment: Separate for each sensing technology.

2. Detector sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an appropriate speed of 12 inches/s.

2.4 LIGHTING CONTACTORS

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

1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP.
3. Eaton Corporation.
4. General Electric Company;
5. Square D.
6. Siemens

B. Description: Electrically operated and mechanically held, combination-type lighting contactors complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served.
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250, hinged enclosure with HOA switch installed in the door. All control wiring shall be wired through the automatic control position.

2.5 DIGITAL WALL SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Lighting Systems; Cooper Control.
2. Hubbell Building Automation.
3. Lutron.
4. WattStopper.
5. ***Acuity Controls.***

B. Low Voltage Momentary Pushbutton Switches in 1, 2, 3, 4, 5 and 8 Button Configuration: Wall switches shall include the following features:
1. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall. Provide custom labeling per direction from the Owner.
2. Configuration LED on each switch that blinks to indicate data transmission.
3. Load/scene status LED on each switch button with the following characteristics:
    a. Bi-level LED.
    b. Dim locator level indicates power to switch.
    c. Bright status level indicates that load or scene is active.
4. Programmable control functionality including:
    a. Button priority may be configured to any level corresponding to networked operation allowing local actions to utilize life safety priority.

b. Scene patterns may be saved to any button. Once set, button may be digitally locked to prevent overwriting of the preset levels.

5. All digital parameter data programmed into an individual wall switch shall be retained in non-volatile FLASH memory within the wall switch itself.

C. Two (2) RJ-45 ports for connection to the room controller local network.

D. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology local network. No additional configuration shall be required to achieve multi-way switching.

E. The following switch attributes may be changed or selected using a wireless configuration tool:
1. Load and scene button function may be reconfigured for individual buttons (from load to scene and vice versa).
2. Individual button function may be configured to toggle, on only or off only.
3. Individual scenes may be locked to prevent unauthorized change.
4. Fade up and fade down times for individual scenes may be adjusted from 0 seconds to 18 hours.
5. Ramp rate may be adjusted for each dimmer switch.
6. Switch buttons may be bound to any load on a room controller and are not load type dependent. Each button may be bound to multiple loads.

2.6 DIGITAL ROOM CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Lighting Systems; Cooper Control; Greengate Room Controller.
2. Hubbell Building Automation; NX Room Controller.
3. WattStopper; DLM Room Controller.
4. Acuity Controls.

B. Digital controllers for lighting automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room controllers shall be provided to match the room lighting control requirements. The controllers will be simple to install and will not have dip switches or potentiometers or require special configuration for standard plug n' go applications. The control units will include the following features:
1. Automatic room configuration to the most energy efficient sequence of operation based upon the devices in the room.
2. Simple replacement: Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf.
3. Multiple room controllers connected together in a local network must automatically prioritize each room controller, without requiring any configuration or setup so that loads are sequentially assigned using room controller devices ID's from highest to lowers.
4. Device status LEDs to indicate:
a. Data transmission.
b. Device has power.
c. Status for each load.
d. Configuration status.
5. Quick installation features including:
a. Standard junction box mounting.

b. Quick low voltage connections using standard RJ-45 patch cable.

6. Based on individual configuration, each load shall be capable of the following behavior on power up following the loss of normal power:
   a. Turn on to 100%.
   b. Remain off.
   c. Turn on to last level.
7. Each load shall be configurable to operate in the following sequences based on occupancy:
   a. Auto-on/Auto-Off (follow on and off).
   b. Manual-on/Auto-off (follow off only).
8. UL 2043 plenum rated.
9. Dual voltage 120/277 VAC, 60 HZ, 20A total load.
10. All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself.

C. On/Off/Dimming Enhanced Room Controllers shall include:
1. Four (4) RJ-45 local network ports with integral strain relief and dust cover.
2. One (1) dimming outlet per relay.
   a. 0-10 V dimming: 0-10 volt output for control of compatible LED drivers. The 0-10 volt output shall automatically open upon loss of power to the room controller to assure full light output from the controlled lighting.
   b. Each dimming output channel shall have an independently configurable minimum and maximum calibration trim level to set the dimming range to match the true dynamic range of the connected ballast or driver.
   c. The LED level indicators on bound dimming switches shall utilize this new maximum and minimum trim.
   d. Each dimming output channel shall have an independently configurable minimum and maximum trim level to set the dynamic range of the output within the new 0-100% dimming range defined by the minimum and maximum calibration trim.
   e. Calibration and trim levels must be set per output channel.
3. Each load shall have an independently configurable preset on level for normal hours and after hours' events to allow different dimmed levels to be established at the start of both normal hours and after hours' events.
4. Fade rates for dimming loads shall be specific to bound switch buttons and the load shall maintain a default value for any bound buttons that do not specify a unique value.

D. Local (Room) Network:
1. The local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building.
2. Features of the local network include:
   a. Plug n' Go automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy efficient sequence of operation based upon the device attached.
   b. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
   c. Push N Learn configuration to change the automatic configuration, including binding and load parameters without tools using only the button son the digital devices in the local network.
   d. Two-way infrared communications for control by handheld remotes and configuration by a handheld tool including adjusting load parameters, sensor

configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

3. Digital room devices connect to the local network using pre-terminated Category 5e cables with RJ-45 connectors which provide both data and power to room devices. Systems that utilize RJ-45 patch cords, but do not provide serial communication data from individual end devices are not acceptable.
4. If manufacturer's pre-terminated Category 5e cables are not used for the installation, the Contractor is responsible for testing each cable following installation and supplying manufacturer with test results.

E. Segment (Room-to-Room) Network: Linear topology to connect local rooms and relay panels.
1. Each connected local network shall include a single network bridge.
2. Network bridges, relay panels and segment managers shall include terminal blocks, with provisions for separate "in" and "out" terminations, for segment network connections.

F. Configuration Tools: A wireless configuration tool facilitates optional customization of local networks using two-way infrared communications, while PC software connects to each local network via a USB interface.

G. Network Bridge: The network bridge module connects a local network for communication between rooms, relay panels and a segment manager. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard communications.

2.7 EMERGENCY POWER CONTROL

A. Comply with the requirements of Division 26 Section "Interior Lighting".

2.8 CONDUCTORS AND CABLES

A. Comply with the requirements of Division 26 Section "Low Voltage Electrical Power Conductors and Cables".

B. Coordinate cabling requirements with lighting control equipment manufacturer and provide as required for a complete installation.

C. Low Voltage Lighting Control Wiring:

1. Category 5 (minimum) quick connect cables: Cables shall be pre-terminated. The Electrical Contractor shall determine lengths required based on field conditions.
2. 0-10 volt dimming wiring: Wiring shall be minimum number 18 gauge, bundled/jacketed and shall be suitable for the installed environment. Coordinate exact wire type, quantity, color, etc. with lighting control equipment manufacturer.
3. Miscellaneous wiring: Wiring shall be suitable for the installed environment. Coordinate exact wire type, quantity, color, etc. with lighting control equipment supplier.
4. All cabling installed above an accessible ceiling shall be plenum rated.

2.9 WALL PLATES

A. Comply with the requirements of Division 26 Section "Wiring Devices."

2.10 FINISHES

A. Comply with the requirements of Division 26 Section "Wiring Devices."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

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 written instructions.

3.2 WIRING INSTALLATION

A. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

B. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

C. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing lighting control devices and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational test: Verify operation of each lighting control device and make additional adjustments as necessary.
3. Verify sensors operate upon entry and do not create false trips while occupied.
4. Verify time delay settings are consistent with manufacturer's recommendation based on room function.

B. Lighting control devices that fail tests and inspections are defective work. Replace device, make necessary adjustments and retest.

C. Verification: Upon completion of installation and testing, engage a manufacturer's field service technician to verify operation of a minimum of 50 percent of installed sensors or as recommended by manufacturer's standard whichever is higher. Technician shall verify sensor placement, quantity, settings, etc., to ensure proper operation, free of false trips.

D. Documentation: Provide documentation for each sensor including the following:

1. Room name.
2. Room number.
3. Device type, including sensor technology, mounting, voltage, and operation.
4. Circuit(s) controlled.
5. Time delay and sensitivity settings.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of project Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two (2) visits to project within this period. Shall include making adjustments to time delay and sensitivity settings to accommodate the functions within each space and to eliminate false trips. Shall also include relocating, adding, and/or repositioning sensors as required for each space. Include all travel, labor, material, etc., costs for no additional expense to the Owner.

3.6 DEMONSTRATION AND TRAINING

A. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner and/or Owner's Representative. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner and/or Owner's Representative after submission and approval of formal training plans. Shall include a minimum of one (1) 4 hour, on-site training sessions.

END OF SECTION 26 09 23

SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

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 dry-type distribution transformers rated 600 V and less.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection.

1. Wiring diagrams: Power, signal, and control wiring.

C. Qualification Data: For testing agency.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

D. Certified as meeting NEMA TP1, Class 1 efficiency levels when tested according to NEMA TP2.

E. Meet or exceed 2016 DOE Efficiency Guidelines.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace equipment and associated components that fail in materials or workmanship within a minimum warranty period of 36 months from date of Project Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.
4. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service and shall comply with TP1 rating.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal coil connections: Brazed or pressure type.
2. Coil material: Aluminum.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated, NEMA 250, Type 2.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish color: ANSI gray.

E. Taps for Transformers: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum temperature rise of 80 deg C above 40 deg C ambient temperature.

G. Energy Efficiency for Transformers:

1. Complying with NEMA TP 1, Class 1 efficiency levels and 2016 DOE Guidelines.
2. Tested according to NEMA TP 2.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems." Nameplate shall include the following information:

1. Transformer designation.
2. Primary and secondary voltage, phase and wire.
3. Fed from circuit number.
4. Equipment served.
5. Arc flash incident energy.
6. Primary and secondary feeder size.

B. Arc Flash Labels: Comply with the requirements defined in Division 26 Section "Electrical System Fault Analysis, Coordination and Arc Flash Study."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written 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 Division 26 Section "Grounding and Bonding for Electrical Systems" have been met.

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

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section "Hangers and Supports for Electrical Systems."

C. Vibration Isolation: Provide neoprene pads for vibration isolation for all transformers located on Floors 1 through 7 and Penthouse.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Transformer core shall be visibly grounded to frame.

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 00

SECTION 26 24 13 - SWITCHBOARDS

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. Service entrance switchboards rated 600V and less.
2. Vertical separation: Complete vertical separation between sections is required for generator entrance switchboard 1HESB1. There shall be separate vertical sections for the following:

    a. MLO section.
    b. Emergency branch section.
    c. Optional Standby branch section.
    d. Legally Required branch section.
    e. Refer to schedule on contract documents for additional requirements.

B. Related Sections including the following:

1. Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding requirements.
2. Division 26 Section "Identification for Electrical Systems" for identification requirements.
3. Division 26 Section “Electricity Metering” for power metering requirements.
4. Division 26 Section "Surge Protection Devices" for switchboard surge protection requirements.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to IBC.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, metering device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail bus configuration, current, and voltage ratings.
3. Detail short-circuit current rating of switchboards and overcurrent protective devices.
4. Detail illustrating additional gutter space requirements for distribution sections.
5. Detail metering equipment, accessories, and connections.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submittal shall also include a list for each overcurrent device provided indicating all upstream and downstream devices that will coordinate with the provided devices.
8. Include schematic and wiring diagrams for power, signal, and control wiring.
9. Series rating of devices are not allowed.
10. Metering circuit diagram.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A Contractor qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E. Contractor shall have minimum of 10 years of experience in installation and testing of this type of equipment.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, metering devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: The drawings and specifications indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: All equipment shall be UL listed and labeled as defined in NFPA 70, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Handle and prepare switchboards for installation according to NECA 400 and NEMA PB 2.1.

1.7 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient temperature: Not exceeding 104 deg F (40 deg C).
    b. Altitude: Not exceeding 6600 feet.

1.8 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace equipment and associated components that fail in materials or workmanship within a minimum warranty period of 36 months from date of Project Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

1. Eaton.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Front-Connected, Front-Accessible Switchboards:

1. Main devices: Fixed, individually mounted; compartmentalized.
2. Branch devices: Fixed, individually mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: 480Y/277 V and 208Y/120V as scheduled on the drawings.

D. Main-Bus Continuous: As per schedule on drawings.

E. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section “Vibration and Seismic Controls for Electrical Systems”.

F. Indoor Enclosures: Steel, NEMA 250, Type 1. Shall be a minimum of #12 gage, reinforced with channels and angles as necessary.

G. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

H. Barriers:

1. Provide barriers separating adjacent switchboard sections.

I. Compartmentalization: The metering, control power and trip unit power supply compartments shall be completely isolated from any energized bus.

J. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

K. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase and neutral bus material: Tin-plated hard-drawn copper of 98 percent conductivity, with tin-plated copper feeder circuit-breaker line connections.
2. Ground bus: 1/4-by-2-inch hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
3. Main phase buses and equipment ground buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
4. Neutral buses: 100 percent of the ampacity of phase buses, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

L. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 SURGE PROTECTION DEVICES

A. Each switchboard shall be protected by an integral mounted surge protection device and shall comply with Division 26 Section “Surge Protection Devices.”

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Feeder Breakers: 100 percent rated, solid-state, electronic-trip circuit breaker with interrupting capacity to meet available fault currents:

1. Solid-state, electronic-trip circuit breakers having microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field adjustable settings:

    a. Functions: Long-time-pickup, long-time-delay, short-time-pickup, short-time-delay, instantaneous pickup, ground-fault-pickup, and ground-fault-delay functions, independent of each other in both action and adjustment.
    b. Current adjustability: Dial settings and rating plugs on trip units.
    c. Equip short-time trip function for switchable I^2t operation.
    d. Ground-fault protection shall have at least three short-time delay settings and three trip-time delay bands; adjustable current pickup for three-wire circuit or system and four-wire circuit or system.
    e. Metering function: Shall be provided with power metering functions with individual digital displays at each breaker trip unit.

2. Trip indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
3. Locking capabilities: Provide all breakers with lock-out/tag-out (LOTO) capabilities to allow a padlock to be installed.

2.4 INSTRUMENTATION

A. Compartmentalization: Provide with the following compartments:

1. Metering compartment: The metering compartment shall be isolated from any energized bus. The metering compartment shall also contain a disconnect switch to disconnect power to the meter and its components, as well as a C.T. shorting block. All components in the metering compartment shall have guarding in place to be considered "finger-safe" with respect to voltage above 50 volts. A flexible non-metallic conduit shall be routed from the metering compartment to the exterior of the switchgear. The raceway will be extended in the field by the Electrical Contractor from the switchgear to the PIC enclosure.
2. Control power and trip unit power supply compartment: The control power components shall be in a compartment isolated from any energized bus. All components in control power and power supply compartment shall have guarding in place to be considered "finger-safe" with respect to voltage above 50 volts.

B. Instrument Transformers: IEEE C57.13, NEMA EI 21.1.

C. Multifunction Digital-Metering Monitor: Comply with the requirements of Division 26 Section "Electricity Metering". Microprocessor-based unit suitable for three- or four-wire systems.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

2.6 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

B. Provide an engraved plastic one-line diagram of each switchboard.

2.7 CONTROL WIRING

A. All control wiring shall be terminated on terminal strips and shall be clearly identified.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install switchboards and accessories according to NECA 400 and NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 3 Section "Miscellaneous Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems" and Section “Vibration and Seismic Controls for Electrical Systems”.

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, metering devices, and instrumentation.

1. Set field-adjustable circuit-breaker trip ranges.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Refer to Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding requirements. Note that the neutral and ground bond shall occur at the generator.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting, and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Provide an engraved plastic one-line diagram for each switchboard and mount to the switchboard front.

E. Arc Flash Labels: Comply with the requirements of Division 26 Section " Electrical System Fault Analysis Coordination and Arc Flash Study " for arc flash labeling.

F. Label each switchboard with the following information:

1. Switchboard designation.
2. Voltage, phase, wire.
3. Ampere.
4. Fed from, circuit number.
5. Short circuit rating.
6. Arc flash incident energy.
7. Feeder size (conduit, wire, ground).

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Circuit breakers:

    a. Visual and mechanical inspection:

        1) Compare equipment nameplate data with drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage and alignment.
        4) Verify the unit is clean.
        5) Operate the circuit breaker to insure smooth operation.
        6) Inspect bolted electrical connections for high resistance using bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 100.12.
        7) Inspect operating mechanism, contacts and arc chutes in unsealed units.
        8) Verify correct operation of any auxiliary features such as trip and pickup indicators, electrical close and trip operation, trip-free and anti-pump functions.

    b. Electrical tests:

        1) Perform adjustments for final setting in accordance with coordination study.
        2) Verify correct operation of any auxiliary features such as trip and pickup indicators, electrical close and trip operation.
        3) Verify operation of charging mechanism.

3. Correct malfunctioning units on-site, where possible and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Switchboard will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated and as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 26 24 13

SECTION 26 24 16 - PANELBOARDS

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. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, accessory, and component indicated. 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. Show tabulations of installed devices, equipment features, and ratings.
2. Details and confirmation that additional gutter space has been provided per the specification.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.

    a. Devices shall be fully rated for available fault current. Series rated devices will not be allowed.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submittal shall include a list for each overcurrent device provided indicating all upstream and downstream devices that will coordinate with the provided devices.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: All equipment shall be UL listed and labeled as defined in NFPA 70 and marked for intended location and application.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

1.6 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace equipment and associated components that fail in materials or workmanship within a minimum warranty period of 36 months from date of Project Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Hangers and Supports for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets as per schedule in Contract Documents.

1. Rated for environmental conditions at installed location.

    a. Indoor dry and clean locations: NEMA 250, Type 1.
    b. Outdoor locations: NEMA 250, Type 3R.
    c. Other wet or damp indoor locations: NEMA 250, Type 4X.

2. Hinged front cover: Panelboard fronts shall be hinged to box type. The locked door must be opened in order to access the screws to open the panelboard front. Panelboards shall require the use of two items to access energized parts, a key and a hand-held tool (screwdriver) to open the cover that exposes energized parts.

    a. Panels with doors over 48 inches high shall have a minimum of two latches per door.

3. Finishes:

    a. Panels and trim: Steel factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back boxes: Galvanized steel.

4. Directory card: Inside panelboard door with protective cover.

C. Incoming Mains Location: Top and bottom per schedule. The Contractor shall be responsible for coordinating feed locations.

D. Phase, Neutral, and Ground Buses:

1. Material: Tin-plated hard-drawn copper, 98 percent conductivity.
2. Equipment ground bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
3. Isolated ground bus: Adequate for branch-circuit isolated ground conductors; insulated from box.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Main and neutral lugs: Mechanical type.
2. Ground lugs and bus-configured terminations: Mechanical type.
3. Feed-through lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
4. Sub-feed (double) lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

F. Temperature Rise Rating: Shall conform to industry standard temperature rise ratings as tested by an independent laboratory.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Locks: Each panelboard shall have two self-latching locks.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series ratings will not be permitted.

2.2 DISTRIBUTION PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Schneider Electric (Square D), I-Line Style or comparable product by of the following:

1. Eaton.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.

B. Main: Circuit breaker or lugs only per Panelboard Schedule.

C. Surge Protection Device: Comply with the requirements of Division 26 Section "Surge Protection Devices."

D. Electronic Trip Circuit Breakers: 80 percent rated, solid-state, electronic-trip circuit breaker with interrupting capacity to meet available fault currents:

1. Solid-state, electronic-trip circuit breakers having microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field adjustable settings:

   a. Functions: Long-time-pickup, long-time-delay, short-time-pickup, short-time-delay, instantaneous pickup, ground-fault-pickup, and ground-fault-delay functions, independent of each other in both action and adjustment.
   b. Current adjustability: Dial settings and rating plugs on trip units.
   c. Equip short-time trip function for switchable I^2t operation.
   d. Ground-fault protection shall have at least three short-time delay settings and three trip-time delay bands; adjustable current pickup for three-wire circuit or system and four-wire circuit or system.

2. Trip indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

E. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-magnetic circuit breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable instantaneous trip setting for circuit-breaker trip sizes 150 amps and larger.
2. Molded-case circuit breaker (MCCB) features and accessories:

a. Bolt-on type.
b. Trip position shall be indicated by means other than the off position.
c. Standard frame sizes, trip ratings, and number of poles.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Multi-pole units enclosed in a single housing or factory assembled to operate as a single unit.
f. Handle padlocking device: Fixed attachment for locking circuit-breaker handle in "on" or "off" position.
g. Handle clamp: Loose attachment for holding circuit breaker handle in "on" position.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

1. Eaton.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only per Panelboard Schedule.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-magnetic circuit breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable instantaneous trip setting for circuit-breaker trip sizes 150 amps and larger.
2. Ground-fault equipment protection (GFEP) circuit breakers: Class B ground-fault protection (30-mA trip).
3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Bolt-on type.
b. Trip position shall be indicated by means other than the off position.
c. Standard frame sizes, trip ratings, and number of poles.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Ground-fault protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
f. Multi-pole units enclosed in a single housing or factory assembled to operate as a single unit.
g. Handle 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.

4. Dual-Function, AFCI/GFCI type:

a. Bolt-on type.
b. Combination type, Class A, 5mA GFCI and AFCI protecting against both arc faults and ground faults.
c. Self-test feature.
d. LED trip indicator.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 3 Section "Miscellaneous Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to panelboards.
5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Mounting: Top most switch or circuit breaker in “on” position shall not be higher than 6’-7” above finished floor or working platform.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker settings per arc flash and short circuit coordination study.

H. Install filler plates in unused spaces.

I. For recessed or semi-recessed panelboards, stub six (6) 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four (4) 1-inch empty conduits into raised floor space or below slab not on grade.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

K. Comply with NECA 1.

L. Bond panelboards to the equipment grounding conductor with the feeder conduit by a threaded grounding type insulated bushing at the conduit entrance into the tub. The equipment grounding conductor shall continue from the bushing to the panelboard ground bus and be bonded.

M. Bond the equipment grounding buses of normal and essential branch circuit panelboards serving the same patient care areas as required by NEC 517. Bond with a minimum #10 awg insulated continuous copper conductor routed in conduit.

N. Dual-Function AFCI/GFCI: All circuit breakers serving receptacles in patient accessible areas shall be dual-function AFCI/GFCI type.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

E. Arc Flash Labels: Comply with the requirements of Division 26 Section "Electrical System Fault Analysis Coordination and Arc Flash Study" for arc flash labeling.

F. Label each panelboard with the following information:

1. Panel designation.
2. Voltage, phase, wire.
3. Ampere.
4. Fed from, circuit number.
5. Short circuit rating.
6. Arc flash incident energy.
7. Feeder size (conduit, wire, ground).

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual, mechanical inspection and electrical test as follows:

a. Certify compliance with test parameters.

2. Circuit breakers, insulated case/molded case:

a. Visual and mechanical inspection:

1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage and alignment.
4) Verify the unit is clean.
5) Operate the circuit breaker to insure smooth operation.
6) Inspect bolted electrical connections for high resistance using bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or Table 100.12.
7) Inspect operating mechanism, contacts, and arc chutes in unsealed units.
8) Verify correct operation of any auxiliary features such as trip and pickup indicators, electrical close and trip operation, trip-free and anti-pump functions.

b. Electrical tests:

1) Perform adjustments for final setting in accordance with coordination study.

2) Verify correct operation of any auxiliary features such as trip and pickup indicators, electrical close and trip operation, trip-free and anti-pump function.
3) Verify operation of charging mechanism.
4) Test insulation resistance for each panelboard bus, component, connecting supply, feeder and control circuit.
5) Test continuity of each circuit.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Panelboards shall be considered defective if they do not pass test and inspections.

D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges per arc flash and short circuit coordination study.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION 26 24 16

SECTION 26 27 26 - WIRING DEVICES

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. Receptacles: Straight blade, GFCI, USB.
2. Twist-locking receptacles.
3. Weather-resistant receptacles
4. Snap switches and wall-box dimmers
5. Floor boxes and poke-through assemblies.
6. Safety type receptacle (tamperproof).

B. Confinement/Institutional Areas: All devices and wall plates installed in an area defined as an inmate area shall be suitable for a Confinement/Institutional area.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. IG: Isolated ground type.

F. TR: Tamper-resistant.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: Provide samples of each type of wiring device and associated wall plate proposed to be installed within areas identified as medium or high risk for review. Product data will not be reviewed prior to the sample review. Devices include, but not limited to, receptacles, switches, lighting control wall stations, occupancy sensors, wall plates and associated tamper-proof screws.

C. Shop Drawings: Provide for each multi-outlet assembly.

1. Provide 1/4" = 1'-0" scale floor plan drawings for each multi-outlet assembly. Provide an identification tag for each raceway with the room number plus identifier.
2. Provide details for each assembly identifying the exact length, mounting details, each device to be installed, cutout openings, covers, hardware, etc., required for the entire assembly.
3. Each receptacle shall be identified with NEMA configuration, panel, circuiting number, voltage, and conductor sizes/quantities.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

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. Comply with NFPA 70.

D. Comply with the latest edition of Facility Guidelines Institute (FGI) Design Guide for the Built Environment of Behavioral Health Facilities.

E. Comply with the latest edition of the New York State Office of Mental Health Patient Safety Standards, Materials and Systems Guidelines. Devices for installation in high or medium risk areas as illustrated on Drawing G110.2 must be shown as accepted in the latest edition of this Guideline.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1. Cord and plug sets: Match equipment requirements.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufactures' packaging-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from a single manufacturer.

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement and FS W-C-596

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper 5351; (single), CR5362(duplex).
b. Hubbell HBL5351; (single), HBL5352 (duplex).
c. Leviton 5891; (single), 5352 (duplex).
d. Pass & Seymour 5361; (single), 5362 (duplex).

2.3 SAFETY TYPE (TAMPER-RESISTANT) RECEPTACLES

A. Tamper-Resistant Convenience receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement sd, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper TR370 (duplex).
b. Hubbell BR20_TR (duplex).
c. Leviton T5850 (duplex).
d. Pass & Seymour TR20W (duplex).

2.4 GFCI RECEPTACLES

A. General Description: Straight blade, non-feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Hospital-Grade, Tamper Resistant, Duplex GFCI Convenience Receptacles, 125 V, 20 A: Comply with UL 498 Supplement SD.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Cooper TRVGFH20.
    b. Hubbell GFR8300SG.
    c. Leviton 7590
    d. Pass & Seymour 2095HGTR.

2.5 STRAIGHT-BLADE USB RECEPTACLES

A. Convenience Duplex Receptacle, 125-volt, 20 amp, Tamper Resistant, Two (2) USB Type 2.0 ports, 3 amp, 5 volt DC. Comply with NEMA WD1, NEMA WD6 Configuration, 5-20R and UL 498 Supplement SD.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Cooper TR7756.
    b. Hubbell USB20X.
    c. Leviton T5832
    d. Pass & Seymour TR5362USB.

2.6 SPECIAL RECEPTACLES

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

1. Cooper.
2. Hubbell.
3. Leviton.
4. Pass and Seymour.

B. Heavy Duty, Specification Grade, Twist Lock, 250V, 30A, 3 Phase: Comply with NEMA WD1, NEMA WD6, Configuration L15-30. Shall be equal to Hubbell HBL2720.

C. Heavy Duty, Specification Grade, Twist Lock, 480V, 30A, 3 Phase: Comply with NEMA Configuration L16-30. Shall be equal to Hubbell HBL2730.

D. Refer to drawings for other NEMA configurations.

2.7 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.

1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
2. External cable grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.8 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.9 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper AH1221 (single pole), AH1222 (two pole), AH1223 (three way), AH1224 (four way).
b. Hubbell; HBL1221 (single pole), HBL1222 (two pole), HBL1223 (three way), HBL1224 (four way).
c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
d. Pass & Seymour; PS20AC1 (single pole), PS20AC2 (two pole), PS20AC3 (three way), 20AC4 (four way).

2.10 LIGHTING CONTROL DEVICES

A. Refer to Division 26 Section “Lighting Control Devices” for requirements related to occupancy sensors, daylight sensors and wall box dimmers.

2.11 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces (Non-Inmate Areas): Smooth, high-impact thermoplastic.
3. Material for Finished Spaces (Inmate Areas): 14-guage steel tamperproof cover. Kenall, Fail-Safe, New Star or equal.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plate: NEMA 250, complying with Type 3R, Weather-resistant, die-cast aluminum with lockable cover.

1. Communications: One 1-1/4-inch conduit.

2.12 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.

1. Wiring devices connected to normal power system: White, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring devices connected to emergency power system: Red.
3. TVSS Devices: Blue

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

1. Receptacles: 18 inches A.F.F. to center unless noted otherwise.
2. Switches/dimmer/wall occupancy sensor: 46 inches A.F.F. to center unless noted otherwise.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Wall Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

F. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

G. Adjust locations of floor boxes and poke through assemblies to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacle and switch cover plates: Identify panelboard and circuit number from which served with a clear label with black lettering.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test instruments: Use instruments that comply with UL 1436.
3. Test instrument for convenience receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line voltage: Acceptable range is 105 to 132 V.
2. Percent voltage drop under 15 amp load: A value of 6 percent or higher is not acceptable.
3. Ground impedance: Values of up to 2 ohms are acceptable.
4. GFCI trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar

problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight blade hospital-grade convenience outlets for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

END OF SECTION 26 27 26

SECTION 26 28 13 - FUSES

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. Cartridge fuses rated 600 V and less for use in switches.

1.3 SUBMITTALS

A. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics and ratings.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Time-current curves, coordination charts and tables, and related data.
4. Fuse size for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

a. Let-through current curves for fuses with current-limiting characteristics.
b. Time-current curves, coordination charts and tables, and related data.
c. Ambient temperature adjustment information.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses from a single manufacturer.

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. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

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. Fuses: Quantity equal to three of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussman, Inc.
2. Ferraz Shawmut, Inc.
3. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

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

3.2 FUSE APPLICATIONS

A. Feeders: Class RK1, time delay.

B. Motor Branch Circuits: Class RK1, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 26 28 13

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following individually mounted, enclosed switches.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. HD: Heavy duty.

C. RMS: Root mean square.

D. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current rating.
4. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports including the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

E. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches.
2. Time-current curves.

1.5 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

C. 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.

1.6 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers:

1. Eaton.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.
4. Square D/Group Schneider.

B. Fusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Non-fusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

D. 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; and labeled for copper and aluminum neutral conductors.
3. Auxiliary contact kit: Auxiliary set of contacts arranged to open before switch blades open.

2.3 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1. Outdoor locations: NEMA 250, Type 3R.
2. Other wet or dry indoor locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

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

3.2 INSTALLATION

A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Variable Frequency Controller Interface: Where an enclosed switch is used in conjunction with a variable frequency controller, route VFC control wiring through auxiliary contact for stopping VFC prior to opening disconnect switch.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Identification for Electrical Systems." Shall include the following information:

1. Designation.
2. Equipment served.
3. Voltage, phase, wire.
4. Feeder size.
5. Fed from circuit number.

C. Arc Flash Labels: Comply with Division 26 Section "Electrical System Fault Analysis, Coordination and Arc Flash Study" for requirements related to arc flash labeling.

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:

1. Inspect mechanical and electrical connections.
2. Verify switch and relay type and labeling verification.
3. Verify rating of installed fuses.
4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

B. Perform the following field tests and inspections and prepare test reports:

1. Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
2. Perform each electrical test and visual and mechanical inspection. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.5 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 26 28 16

SECTION 26 29 16 ENCLOSED CONTACTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes enclosed contactors for lighting and general purposes.

1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
2. NEMA FU 1 - Low Voltage Cartridge Fuses.
3. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
4. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.
5. NEMA ICS 6 - Industrial Control and Systems: Enclosures.
6. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

A. Product Data: Submit dimensions, size, voltage ratings and current ratings.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations and ratings of enclosed contactors.

B. Operation and Maintenance Data: Submit instructions for replacing and maintaining coil and contacts.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

PART 2 - PRODUCTS

2.1 LIGHTING CONTACTORS

A. Manufacturers:

1. Square D
2. Allen Bradley
3. EATON/Cutler Hammer
4. Siemens Industry, Inc.
5. Substitutions: Not Permitted.

B. Product Description: NEMA ICS 2, magnetic lighting contactor.

C. Configuration: Mechanically held, 3 wire control.

D. Coil operating voltage: 120 volts, 60 Hertz.

E. Poles: To match circuit configuration and control function.

F. Contact Rating: Match branch circuit overcurrent protection, considering derating for continuous loads.

G. Accessories:

1. Cover Mounted Pilot Devices: NEMA ICS 5, heavy-duty type with Form Z contacts, rated A150.
2. Selector Switch: ON/OFF/AUTOMATIC function, with rotary action.
3. Indicating Light: GREEN lens, transformer type, with led lamp.
4. Auxiliary Contacts: 2 normally open and 2 normally closed in addition to seal-in contact.
5. Relays: NEMA ICS 2.
6. Control Power Transformers: 120 volt secondary, 24 VA minimum, in each enclosed contactor. Furnish fused [primary and] secondary, and bond unfused leg of secondary to enclosure.

H. Combination Contactors: Combine contactors with enclosed knife switch conforming to NEMA KS 1, with externally operable handle and fuse clips designed to accommodate NEMA FU 1, Class R or J fuses.

I. Enclosure: NEMA ICS 6, to meet conditions. Fabricate enclosure from [steel finished with manufacturer's standard gray enamel aluminum.

1. Interior Dry Locations: Type 1.
2. Exterior Locations: Type 3R.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install enclosed contactors [as indicated on Drawings], in accordance with NECA "Standard of Installation."

B. Install enclosed contactors plumb. Provide supports in accordance with Section 26 05 29.

C. Height: 5 ft (1500 mm) to operating handle.

D. Install fuses for fusible switches. Refer to Section 26 28 13 for product requirements.

E. Install engraved plastic nameplates. Refer to Section 26 05 53 for product requirements and location.

3.2 FIELD QUALITY CONTROL

A. Execution Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.16.1.

END OF SECTION 26 29 16

SECTION 26 32 13 – ENGINE GENERATORS

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 a 600KW, 750 KVA, 480Y/277V, 3-phase/4-wire grounded neutral, 60 Hz packaged engine generator set for use in a standby emergency system. Unit shall be factory assembled, tested, and certified to operate at stated ratings. Shall have the following features:

1. Diesel engine.
2. Unit-mounted cooling system.
3. Unit-mounted control and monitoring.
4. Outdoor, sound attenuated enclosure.
5. Sub-base fuel tank.
6. Unit shall meet EPA Tier 2 requirements and shall be EPA certified for emergency standby use.
7. Remote annunciator.
8. Generator breakers.

B. Related Sections include the following:

1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.
2. Division 01 Section “General Commissioning”.
3. Division 26 Section “Commissioning of Electrical Systems”.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. Standby Rating: Power output rating equal to the power the generator set delivers continuously under normally varying load factors for the duration of a power outage.

C. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

1.4 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage and decrement curve for generator.
2. Time-current characteristic curves for generator protective device.
3. Engine and generator specifications and operating characteristics.
4. Muffler, radiator, and sound attenuation specifications. Include dB levels at the following distances: 1, 7 and 15 meters.
5. Engine instruments and control panel.
6. Radiator coolant system.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, foundation requirements, required clearances, method of field assembly, components and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
2. Design calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration isolation base details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
4. Wiring diagrams: Power, signal, and control wiring.
5. Sub-base tank dimension and wiring diagram.
6. Battery and charger data, including sizing calculations. Also include details of lockable battery disconnect switch.
7. Mechanical piping schematics.

C. Source quality-control test reports.

1. Certified test reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
2. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
3. Report of sound generation.
4. Report of exhaust emissions showing compliance with applicable regulations.
5. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

F. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 60 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs. The manufacturer shall assemble, and factory test the unit. The dealer shall take delivery from the factory and complete assembly of all dealer supplied options.

C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

D. 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.

E. Comply with ASME B15.1.

F. Comply with NFPA 37.

G. Comply with NFPA 70.

H. Comply with NFPA 99.

I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

J. Comply with UL 2200 and be labeled accordingly.

K. Comply with OSHA 3124.

L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

1. Comply with applicable EPA requirements.
2. Comply with New Source Performance Standard (NSPS) for Stationary Reciprocating Compression Ignition Engines.

M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1. Noise level shall be no greater than 75 dB measured at 23-feet from the unit in all directions.

1.6 PROJECT CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient temperature: Minus 25 to plus 50 deg C.
2. Relative humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet.

1.7 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators and sub-base fuel tank. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3. The concrete pad shall extend a minimum of 48-inches from the generator base on all sides.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty period: Two years from date of Project Substantial Completion.

B. Battery Warranty: Manufacturer's standard form in which manufacturer agrees to replace battery that fails within specified warranty period.

1. Warranty period: Three years from date of Project Substantial Completion.

C. Extended Warranty: Manufacturer's standard form in which manufacturer agrees to provide parts and service on engine and accessories, generator, exciter, and system controls.

1. Extended warranty period: Seven additional years beyond the above stated two year warranty for a total of ten years from date of Project Substantial Completion.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Project Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include semi-annual exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 COMMISSIONING

A. Commissioning of components, equipment and/or system specified in this division is part of the construction process. Project closeout is dependent on successful completion of all commissioning procedures, documentation and issue closure. See Section 01 91 13 for detailed commissioning requirements.

1.11 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 each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Caterpillar; Engine Div.
2. Cummins Power Generation; Industrial Business Group.
3. Generac Power Systems.
4. Kohler Power Systems.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power output ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Output connections: Three-phase, four wire. Extend all leads to a main termination box adequate in size to make all terminations including neutral and ground. Neutral shall be isolated from ground and shall maintain lugs for connection from normal and engine generator source and load wires.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

4. Harmonic distortion: Less than 5 percent.
5. Telephone influence Factor: Less than 50.

D. Generator-Set Performance:

1. Steady-state voltage operational bandwidth: 1 percent of rated output voltage from no load to full load.
2. Transient voltage performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-state frequency operational bandwidth: 0.25 percent of rated frequency from no load to full load.
4. Steady-state frequency stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Sustained short circuit current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
6. Start and load transfer time: Comply with NFPA 110, Type 10, system requirements (load transfer under 10 seconds).
7. Excitation system: Performance shall be unaffected by voltage distortion caused by non-linear load. Provide permanent magnet excitation for power source to voltage regulator.

2.3 ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Type: Industrial, multi-cylinder, four-stroke, 1800 rpm.

C. Output Connections:

1. Frequency drop acceptable to load.
2. Stable frequency regulating.
3. Accept 100 percent block load.
4. Frequency dip acceptable to load.

D. Lubrication System:

1. Description: Full pressure, engine-driven, positive displacement sump pump.
2. Filter and strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
3. Thermostatic control valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
4. Crankcase drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Description: Fuel system complete with fuel filter and priming pump.

2. Main fuel pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
3. Relief bypass valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Coolant Jacket Heater: Electric-immersion type. Shall be cord and cap connected (hard-wired not allowed). Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Shall maintain engine coolant and lube oil temperature to allow for fast starting. Shall be piped remotely with shutoff service and drain valves.

G. Governor: Adjustable isochronous, with speed sensing, suitable for providing accurate speed control and droop stabilization.

1. Electronic type, steady-state speed band at 60 Hz, 0.25 percent of rated frequency from no load to full load. Speed droop shall be adjustable from zero percent to seven percent for load application from no load to full load.
2. Shall comply with NFPA 110 requirements for block load capacity.
3. Manual speed adjustment available while engine is running.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump. Radiator air outlet shall be located on top of sound attenuated enclosure for vertical discharge.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of radiator: Adequate to contain expansion of total system coolant from cold start to 100 percent load condition and rated for 110 deg F ambient temperature.
3. Temperature control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
4. Coolant hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
    b. End fittings: Flanges or steel pipe nipples with two clamps to suit piping and equipment connections.

I. Muffler/Silencer: Critical grade, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 23 feet from exhaust discharge after installation is complete shall be 75 dBA or less.
3. Muffler/silencers shall be installed within sound attenuated, outdoor enclosure.

J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

K. Battery System: 24-V electric, with negative ground.

1. Components: Sized so they shall not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
2. Cranking motor: Heavy-duty cranking motor with drive mechanism that automatically engages and releases from engine flywheel without binding. Shall be capable of cranking engine five times in rapid succession without overheating and with sufficient speed within specified temperature range per Part 1 "Project Conditions."
3. Cranking cycle: As required by NFPA 110 for system level specified and shall have 90 second adjustable cycle cranking for crank rest period. Adjusted for 5 cranking cycles of 15 seconds "ON" and 15 seconds "OFF" with over-ranking relay.
4. Battery: Heavy-duty sealed lead acid with adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least five times consecutively without recharging.
5. Battery cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery rack: Provide suitable battery rack with acid resistant finish to support and fasten batteries in place.
7. Heating pad or blanket: Provide self-regulating heating pad or blanket to maintain temperature 40 deg F to 55 deg F.
8. Disconnect: Provide master disconnect switch with lockout lever kit allowing for multiple padlocks or lockout system hasps.
9. Battery-charging alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
10. Battery charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic temperature compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic voltage regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and mounting: NEMA 250, Type 1, wall-mounted cabinet.
    g. Shall be provided with a cord and plug arrangement.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank shall be double wall construction and shall be sized to provide 48-hour operation at full load capacity with leak detector in double wall. Include audio and visual alarm in the event of leak. Shall comply with all applicable EPA spill containment requirements.
2. Vandal-resistant fill cap.
3. Fuel level gauge at fill pipe location.
4. The tank shall be supplied with a 2" threaded fill connection, engine fuel supply and return connections with standpipes.
5. The tank shall also be supplied with mounting rails that will support the spring isolators that are between the tank and the engine/generator base.
6. Vent lines, include working and emergency vent for both inner and outer tank.
7. Low-level alarm sensor: Separate device operates alarm contacts at 50 percent of normal fuel level.
8. Leak detection sensor: Provide in the tank interstitial space and arranged to provide full leak alarm at control panel.

2.5 GENERATOR CONTROL AND MONITORING

A. Operator Controls: Control functions shall include manual/off/auto selector switch, engine start push button, engine stop push button, and circuit breakers.

B. Manual and Automatic Start Operation:

1. Complete automatic engine starting and load transfer after sensing an adjustable predetermined single or multiple phase voltage sag.
2. Upon restoration of normal power, sequence phase rotation and automatically transfer load back to normal source and shut the engine generator down.
3. Manual-off-automatic selector on generator control panel:

a. Resetting of the automatic engine control after a failure by moving the selector switch from "Auto" to "Off" and then back to "Auto."
b. Manual starting and stopping of the engine without transferring the load when placing the selector switch in the "Manual" position.
c. Prevent any operation of the engine generator in any mode when placing the selector switch in the "Off" position.

C. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, contacts from remote automatic transfer switches initiate starting and stopping of generator set. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of the emergency-stop switch located within the control panel enclosure also shuts down generator set.

D. Manual Starting System Sequence of Operation: Switching "ON-OFF" switch on the generator control panel to the "ON" position starts generator set. The "OFF" position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

E. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator circuit breaker, and other indicated components shall be grouped in a combination control, monitoring, and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Mounting method shall isolate the control panel from generator set vibration.

F. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. DC ammeter (battery charging).
6. AC kilowatt hour meter.
7. Fuel pressure meter
8. Engine-coolant temperature gage.
9. Engine lubricating-oil pressure gage.
10. Running-time meter.
11. Ammeter-voltmeter, phase-selector switch(s).
12. Generator-voltage adjusting rheostat.
13. Start-stop switch.
14. Overspeed shutdown (between 115 percent and 125 percent of rated speed) device and shutdown alarm.
15. Coolant high-temperature shutdown device and shutdown pre-alarm and alarm.
16. Coolant low-level shutdown device and shutdown alarm.
17. Oil low-pressure shutdown (adjustment set to operate when oil pressure drops below manufacturers recommendation) device and shutdown pre-alarm and alarm.
18. Fuel tank derangement alarm.
19. Fuel tank high-level shutdown of fuel supply alarm.
20. Generator overload.
21. Ground fault indication (main breakers).
22. Low coolant level.
23. Failure to crank alarm.
24. Failure to generate alarm.
25. Over-crank shutdown and alarm (adjustable from 15 to 60 seconds).

G. Safety Controls: Shall shut down the engine and open the generator circuit breakers. Controls shall be programmed to record and store alarms as well as safety actuation. Alarm should be adjustable by the Owner. Cutouts should only be adjustable by manufacturer's field service technician.

H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

I. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Control panel shall include Ethernet port for interface with building automation on RS 485 and TCP/IP connection for all alarm and status function.

J. Remote Alarm Annunciator: Comply with NFPA 110. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. Locate in Fire Command Center.

K. Generator control and monitoring panel shall be installed at 6'-6" work surface to top above generator access platform.

L. Remote Emergency Stop Switch: Flush, wall mounted. Push button shall be labeled and protected from accidental operation. Locate in Fire Command Center.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker:

1. 100 percent rated, solid-state, electronic-trip, microprocessor based trip units with interchangeable rating plug, trip indicators, and the following field adjustable settings:

   a. Functions: Long-time pickup, long-time delay, short-time pickup, short-time delay, instantaneous pickup, independent of each other in both action and adjustment.
   b. Ground-fault detection providing an audible and visual alarm locally and at the annunciator. Shall not trip breaker.
   c. Adjustability: Dial settings and rating plugs on trip units.
   d. Equip short-time trip function for switchable I^2t operation.
   e. Ratings: Breaker shall be 1600 amp-/3-Pole/480-Volt/65 KAIC.
   f. Shunt-trip capabilities.
   g. Auxiliary contacts to monitor position.
   h. Pad-lockable for lockout requirements.
   i. Mounting: Integrated with or adjacent to the generator control panel. Enclosures shall be suitable for the installed environment.
   j. Kirk key interlock: Coordinate with generator docking station.

B. Ground Fault Indication: Comply with NFPA 70 for ground fault. Integrate ground fault alarm indication with other generator set alarm indications. Ground fault protection shall not trip the circuit breaker.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor. Shall be directly connected to the generator field windings without intervening brushes, slip rings, or communicators. Not less than six solid state rectifiers and surge protectors.

C. Electrical Insulation: Class H, rated at maximum 105 deg C rise over a 40 deg C at 100 percent rating.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over-speed up to 125 percent of rating, and heat during operation at 100 percent of rated capacity.

F. Instrument Transformers: Mounted within generator enclosure.

G. Voltage Regulator: Solid-state type, static type, three phase voltage regulator separate from exciter, providing performance as specified.

1. Voltage band widths shall not exceed ±0.5 percent and ±1 percent of their mean value for constant loads from no load to full load.

H. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

I. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

2.8 SOUND ATTENUATION TYPE OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, sound attenuated, weatherproof steel housing, non-walk-in type, wind resistant up to 100 mph. Multiple panels shall be lockable and provide complete access to components requiring maintenance. Instruments and control shall be mounted within enclosure. The sound attenuated enclosure shall be provided with the following features:

1. Construction: Heavy duty, 14 gage sheet metal, integral structural-steel-framed set on concrete foundation. Stainless steel fasteners.
2. Structural design and anchorage: Comply for wind loads.
3. Louvers: Arranged to permit air circulation while excluding exterior dust, birds, and rodents.
4. Hinged doors: All doors shall be hinged type with padlocking provisions. Doors shall also be provided with hardware for removing of panels. Lift off panels are not acceptable unless they are hinged.
5. Insulated metal panels: To limit the sound level to maximum 75 dB at 23 ft. away.
6. Internally mounted critical exhaust silencing system.
7. Provide a means of access to all fluid fill and inspection points.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 100 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

C. Interior Lights with Switch: Factory-wired, vapor-proof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. DC lighting system and connection point for operation when remote source is available.

D. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

E. Finish: Exterior finish shall be custom color as selected by the Architect.

2.9 POWER DISTRIBUTION PANEL

A. Description: Power distribution panel located within the sound-attenuated, outdoor enclosure to serve all auxiliary power requirements including, but not limited to, lights, receptacles, heaters, chargers, etc. Panel shall be a single point connection with all circuits pre-wired by manufacturer. Size all breakers and feeders per NEC requirement.

B. Rating: 120/208 volt, single-phase, three-wire, 100 Amp with main breaker.

C. Manufacturers: Acceptable manufacturers are Eaton, Siemens, Square D and General Electric.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a non-slip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene.
2. Durometer rating: 50.
3. Number of layers: Three.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Corrosion resistant pre-treatment and compatible primer.

1. Finish: Exterior finish shall be a custom color as selected by the Architect.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.

4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Maximum and continuous net brake horsepower over the operating speed range of the engine.
9. Provide 14 day advance' notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch on 4-inch high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Electrical Supports and Seismic Restraints."

1. The concrete pad shall extend a minimum of 48-inches from the generator base on all sides.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

A. Identify system components according to Division 26 Section "Identification for Electrical Systems."

B. Arc Flash Labeling: Comply with Division 26 Section "Electrical System Fault Analysis, Coordination and Arc Flash Study" for arc flash labeling requirements.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA acceptance testing specification: Certify compliance with test parameters.
2. NFPA 110 acceptance tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.
4. Battery-charger tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System integrity tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Set up and test all controls; verify operation and adjustment of mechanical systems.

D. Coordinate tests with tests for transfer switches and run them concurrently.

E. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

F. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

J. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 LOAD BANK FOR GENERATOR TESTING

A. Apply the following loads using a portable resistive load bank with recording kilowatt hours metering:

1. Start and idle for 10 minutes.
2. Operate generator set at 25 percent rated load for 60 minutes.
3. Operate generator set at 50 percent rated load for 60 minutes.
4. Operate generator set at 75 percent rated load for 60 minutes.
5. Operate generator set at 100 percent rated load for 120 minutes.

B. Block Load Test: Perform a 100 percent block load test with resistive load bank. Additional run time after this test is not required. Cool down engine and shut down. Log load data, voltage, and frequency during test.

C. Single Step Full Load Pickup Test with Building Load:

1. Simulate power failure at all automatic transfer switches simultaneously. Run genset for minimum 30 minutes under single step full load pickup test. Cool down engine and shut down. Log load data, voltage, and frequency during test.

D. Test Log:

1. A test log shall be made of the above installation tests and readings shall be taken and recorded at 15 minute intervals noting:

a. Engine oil pressure; if unit includes an after cooler, also record leaving oil temperature.

b. Water temperature of block, entering and leaving the radiator; if installation includes a heat exchanger, water temperature of entering and leaving engine and heat exchanger.
c. Ambient room temperature, room intake air temperature, and exhaust air temperature.
d. Voltage of each phase.
e. Ampere of each phase, neutral and grounding conductor.
f. Time delay on start and time required to come up to operating speed.
g. Frequency.
h. Battery charge rate at 5-minute intervals for first 15 minutes and at 15-minute intervals thereafter.
i. Voltage and frequency variation due to load changes during testing.

3.7 FUEL

A. The Contractor shall be responsible for providing fuel. This shall include the initial fuel, fuel required during testing, and final filling after testing is complete. The Owner shall be provided with a full tank at handover at project Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 26 32 13

SECTION 26 36 00 - TRANSFER SWITCHES

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 transfer switches rated 600 V and less, including the following:

1. Automatic, closed transition, bypass/isolation switches.
2. Remote annunciation and control system.

B. Project Restrictions:

1. Dimensions: The maximum dimensions allowed for each transfer switch shall be 38-inches wide by 39-inches deep. Switches with dimensions larger than these will not be approved without Engineer of Record written permission.
2. Access: Each transfer switch shall require front access only. Switches requiring side or rear access will not be approved.

C. Related Sections include the following:

1. Division 01 Section “General Commissioning”.
2. Division 26 Section "Engine Generators."
3. Division 26 Section “Commissioning of Electrical Systems”.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-line diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. 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. Dimensioned outline drawings of equipment unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within 60 miles of the project site.

B. Source Limitations: Obtain automatic closed transition bypass isolation switches, remote annunciator and control panels through one source from a single manufacturer.

C. 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.

D. Comply with NEMA ICS 1.

E. Comply with NFPA 70.

F. Comply with NFPA 99.

G. Comply with NFPA 110.

H. Comply with UL 1008 unless requirements of these Specifications are stricter.

I. Comply with IBC 2006 for seismic requirements.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace equipment and associated components that fail in materials or workmanship within a minimum warranty period of 36 months from date of Project Substantial Completion.

1.7 COMMISSIONING

A. Commissioning of components, equipment and/or system specified in this division is part of the construction process. Project closeout is dependent on successful completion of all commissioning procedures, documentation and issue closure. See Section 01 91 13 for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Emerson; ASCO Power Technologies, LP.
2. Russelectric, Inc.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles. Solid/common neutral will not be permitted.

H. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."

1. Designated terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-terminal arrangement and field wiring space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control wiring: Equipped with lugs suitable for connection to terminal strips.

I. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

J. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

E. Digital Communication Interface: Matched to capability of remote annunciator and control panels.

F. Include the following functions and characteristics for automatic closed transition transfer switches:

1. Fully automatic make-before-break operation.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of no interruption transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

G. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

H. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

I. Automatic Transfer-Switch Features:

1. Under-voltage sensing for each phase of normal source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable time delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/frequency lockout relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time delay for retransfer to normal source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained under-voltage of emergency source, provided normal supply has been restored.
5. Test switch: Simulate normal-source failure.
6. Switch-position pilot lights: Indicate source to which load is connected.

7. Source-available indicating lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal power supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency power supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned auxiliary contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer override switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine starting contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine shutdown contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-generator exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser transfer selector switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is not available.

13. Generator load bank load dump feature: Provide a load dump auxiliary contact within each automatic transfer switch that will initiate the load dump feature at a portable load bank. The purpose of this feature is to prevent the generator from seeing load applied via a portable load bank when the building calls for emergency power via the transfer switches.
14. BMS interface: Provide contacts as required for BMS interface to monitor each transfer switch as follows:

    a. Switch in normal position.
    b. Switch in emergency position.
    c. Switch in bypass.

15. Elevator interface: Provide contacts for pre and post transfer communication to/from elevator controllers. Coordinate requirements with elevator supplier.

J. Include the following functions and characteristics for bypass/isolation switches:

1. Comply with requirements for Level 1 equipment according to NFPA 110.
2. Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources.

3. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
4. Draw-out arrangement for transfer switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
5. Bypass/isolation switch current, voltage, closing and short circuit withstand ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
6. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
7. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
8. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
9. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
10. Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

K. Terminal provisions for a remote contact which opens to signal, the CTTS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial port.

L. One set of double pole, double throw contacts that operate when normal source voltage is available and one set of double pole, double throw contacts that operate when emergency source voltage is available.

M. Load shedding circuit initiated by the removal of the control voltage to a relay to match generator capacity to the load. Relay de-energization transfer load to the normal source, regardless of its acceptability. 24 VDC customer supplied control voltage.

2.4 DIGITAL POWER METER

A. Provide an integral digital power meter flush mount in each transfer switch. The meter must be in same manufacturer and model as provided at the low voltage switchgear. Comply with the requirements of Division 26 Section “Electricity Metering”.

2.5 REMOTE ANNUNCIATOR AND CONTROL SYSTEM

A. Functional Description: Include the following functions for indicated transfer switches:

1. Indication of sources available as defined by actual pickup and drop-out settings of transfer switch controls.
2. Indication of switch position.
3. Indication of switch in test mode.
4. Indication of failure of digital communication link.
5. Key switch or user code access to control functions of panel.

6. Control switch test initiation.
7. Control of switch operation in either direction.

B. Malfunction of annunciator, annunciation and control panel or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to standalone, self-contained operation. Automatic transfer switch sensing, controlling or operating function shall not depend on remove panel for proper operation.

C. Remote Annunciation and Control Panel: Solid state components. Include the following features:

1. Controls and indicating lights grouped together for each transfer switch.
2. Label each indicator light control group. Indicate transfer switch it controls, location of switch and load it serves.
3. Digital communications capability: Matched to that of transfer switches supervised.
4. Mounting, flush, modular, steel cabinet unless otherwise indicated.

2.6 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Hangers and Supports for Electrical Systems" and Section “Vibration and Seismic Controls for Electrical Systems”.

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

C. Arc Flash Labeling: Comply with Division 26 Section "Electrical System Fault Analysis, Coordination and Arc Flash Study" for arc flash labeling requirements.

D. Identify components according to Division 26 Section "Identification for Electrical Systems." The labels shall be viewable from the front of the equipment without opening any doors or covers. Include the following information:

1. Designation.

2. Fed from normal and emergency.
3. Equipment served.
4. Voltage, phase, wire.
5. Ampere.
6. Feeder sizes.

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary, to accommodate required wiring.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

D. Generator Load Bank Load Dump Feature: Provide wiring from the load dump auxiliary contact within each automatic transfer switch to the generator load bank docking station to prevent load bank operation when building calls for emergency power. Independent and separate sets of conductors shall be provided from each transfer switch out to the terminal strip in the first load dump enclosure.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.

b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
b. Simulate loss of phase-to-ground voltage for each phase of normal source.
c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
f. Test closed transition unit functional modes and related automatic transfer switch operations.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

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

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 00

SECTION 26 43 14 – SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes surge protection devices for low-voltage power equipment.

B. Related Sections include the following:

1. Division 26 Section "Switchboards."
2. Division 26 Section “Panelboards.”

1.2 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. VPR: Voltage Protection Rating.

C. SPD: Surge Protection Device.

1.3 SUBMITTALS

A. Product Data: Provide information for each type of product indicated. Information shall be specific to the products being supplied for the project and shall include the following: rated capacities, unit dimensions, weights, mounting provisions, wiring diagrams, including recommended breaker and wire sizes, installation instructions and accessories.

B. Product Certificates: Provide documentation, signed by product manufacturer, certifying compliance with the following standards:

1. The SPD ratings for the manufacturer and specific model number(s) must be listed on the UL On-Line Certification Website under Category VZCA. Include in submittal.
2. UL 1449 – 4th Addition.
3. NEC Article 285 – 2014 Edition Compliant.
4. UL96A and NFPA 780. Illustrate compliance with UL master label per Division 26 Section “Lightning Protection for Structures”.
5. Provide test reports demonstrating compliance with UL 1449-4 for Tested Inominal, Tested SCCR, and Tested MCOV.

C. Field quality-control test reports, including the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

D. Operation and Maintenance Data: For surge protection devices to include in emergency, operation, and maintenance manuals.

E. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain surge protection devices and accessories through one source from a single manufacturer.

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. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."

D. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."

E. Comply with UL 1449 – 4th Edition, "Standard for Safety for Surge Protective Devices."

F. Shall be UL listed and labeled. SPD ratings for the manufacturer and specific model number must be listed on the UL On-Line Certification Website.

1.5 PROJECT CONDITIONS

A. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:

1. Maximum continuous operating voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating temperature: 30 to 120 deg F (0 to 50 deg C).
3. Humidity: 0 to 85 percent, non-condensing.
4. Altitude: Less than 20,000 feet (6090 m) above sea level.

1.6 COORDINATION

A. Coordinate surge protection device ratings with the AIC rating of the equipment being protected. The rating of the surge protection device must be equal to or greater than the rating of the protected equipment.

B. Coordinate size of overcurrent protection and wiring serving surge protection devices. Provide according to manufacturer’s recommendation.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fails in materials or workmanship within ten years from date of Project Substantial Completion. The warranty shall cover unlimited replacement of surge protection devices or components during the warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Surge Protection Devices:

1. Advanced Protection Technologies.
2. Current Technology.
3. LEA International.
4. Liebert Corporation.

2.2 SUPPRESSORS DESCRIPTION

A. Surge Protection Device Description: Sine-wave-tracking type with the following features and accessories:

1. MOV shall be configured in each L-N, L-G and N-G mode and shall be rated for unit rating.
2. MOV’s shall be large block and individually protected.
3. Fabrication using bolted lugs for internal wiring.
4. Integral disconnect switch or feeder breaker which allows to remove device for replacement without shutdown of panel/switchboard.
5. Arrangement with bus/wire connections to phase buses, neutral bus, and ground bus.
6. LED indicator lights for power and protection status.
7. Audible alarm, with silencing switch, to indicate when protection has failed.
8. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
9. Surge-event operations counter.

B. UL 1449-4 Tested Inominal: 20 KA.

C. UL 1449-4 Tested SCCR: 200 KA.

D. UL 1449-4 Tested MCOV:

1. 208Y/120V: 150 V.
2. 480Y/277V: 320 V.

E. Protection Modes: The voltage protection rating (VPR) per UL 1449 4th Edition 6KV/20KA testing shall be as follows:

1. 480/277 volt, 3 phase, 4 wire system.

a. L-N, L-G and N-G: 1,100V-1,300V.
b. L-L: 1,900V-2,100V.

2. 208/120-volt, 3 phase, 4 wire system:

a. L-N, L-G and N-G: 650V-850V.
b. L-L: 1,100V, 1,300V.

F. Fuses:

1. All protection modes shall be internally individually fused. The fuses I^2t capacity shall allow the suppressor's maximum rated transient current to pass through the suppressor without fuse operation. If the rated I^2t of the fuse is exceeded, the fuse shall open and clear both high and low impedance fault conditions. All overcurrent devices shall be monitored including those on the N-G mode and will provide indication of suppressor component failure or operability. Internal protection shall be included to protect against overheating for temporary over voltage condition.

G. Short Circuit Rating:

1. The SPD shall be marked with a short circuit rating and shall not be installed at a point on the system where the available fault current is in excess of that rating.

2.3 SUPPRESSORS

A. Switchboard SPD:

1. Minimum surge current rating: 200 KA per mode/400 KA per phase.
2. Connection AWG: Per manufacturer.
3. Overcurrent protection (breaker): Per manufacturer.
4. Shall comply to Category Type "1."
5. Provide unit with integral disconnect, allow unit to be replaced without interruption of power to board.
6. Mounting: Integral to switchboard in an isolated, dedicated compartment.

B. Distribution Panelboards SPD:

1. Minimum surge current rating: 100 KA per mode/200 KA per phase.
2. Connection AWG: Per manufacturer.
3. Overcurrent protection (breaker): Per manufacturer.
4. Shall comply to Category Type “2.”
5. Provide unit with integral disconnect, allow unit to be replaced without interruption of power to board.
6. Provide unit in separate NEMA-1 enclosure and field wired.

2.4 ENCLOSURES

A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTION DEVICES

A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.

B. Install devices for panelboard and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

C. Provide multi-pole circuit breaker as a dedicated disconnect for suppressor, where applicable, unless otherwise indicated.

3.2 PLACING SYSTEM INTO SERVICE

A. Do not energize the source until surge protection devices are installed, connected and tested.

3.3 FIELD QUALITY CONTROL

A. Testing: Perform the following field tests and inspections and prepare test reports:

1. After installing surge protection devices, but before electrical circuitry has been energized, test for compliance with requirements.
2. Complete startup checks according to manufacturer's written instructions.
3. Perform each visual and mechanical inspection and electrical test as follows. Certify compliance with test parameters.

    a. Compare equipment nameplate data with drawings and specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding and clearances.
    d. Verify the arresters are clean.
    e. Inspect bolted electrical connections for high resistance by calibrated torque-wrench method in accordance with manufacturer’s published data or Table 100.12.
    f. Verify that ground lead on each device is individually attached to a ground bus or ground electrode.
    g. Perform insulation resistance tests. Use manufacturer’s recommended values.

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

END OF SECTION 26 43 14

SECTION 26 51 00 - INTERIOR LIGHTING

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. Interior lighting fixtures, LED modules and drivers.
2. Exit signs.
3. Emergency power control devices.
4. Lighting fixture supports.

B. Related Sections include the following:

1. Division 26 Sections "Lighting Control Devices" for the automatic control of lighting.

1.3 DEFINITIONS

A. CRI: Color-rendering index.

B. LER: Luminaire efficacy rating.

C. Luminaire: Complete lighting fixture, including ballast housing if provided.

D. EPC: Emergency Power Control device.

E. Tunable White: Technology enabling the control of white light between CCT of 2700 Kelvin to 6500 Kelvin intended to mimic natural daylight.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of all products listed above including dimensions.
2. LED information.
3. Driver information, including catalog numbers, power consumption, etc.
4. Life, output, and energy-efficiency data.
5. Photometric data, in .IES format, based on laboratory tests of each lighting fixture type, outfitted with LED modules, drivers and accessories identical to those indicated for the

lighting fixture as applied in this Project. The IES files shall be for the exact fixture and configuration for this project.

B. Shop Drawings: Show wiring diagrams for generator transfer devices.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

E. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Defined by OSHA in 29 CFR 1910.7.

B. Electrical Components, Devices, and Accessories: All equipment shall be UL listed and labeled as defined in NFPA 70, Article 100 and marked for intended use.

C. Comply with NFPA 70.

D. LED Lighting: Shall comply with the requirements of IESNA LM-79 and LM-80.

E. Emergency Power Control devices and exit lights shall be UL 924.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate ceiling type with reflected ceiling plan and provide appropriate mounting frame for specified light fixture. Light fixture model/series on fixture schedule on drawing does not specify type of trim.

1.7 WARRANTY

A. Warranty for Drivers: Manufacturer's standard form in which driver manufacturer agrees to repair or replace drivers that fail in materials or workmanship within specified warranty period.

1. Warranty period for Led drivers: Five years from date of Project Substantial Completion.

B. Warranty for LED Products: Manufacturer’s standard form in which manufacturer agrees to repair or replace LED products that fail in materials or workmanship within specified warranty period.

1. LED products: Shall apply to the entire LED product including, but not limited to, LED, LED modules, drivers, housing, lens, paint, etc. Replace items that fail and/or the light

output has decreased below the L70 values within five years from date of Project Substantial Completion.

C. Warranty for Emergency Power Control Devices: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Five (5) years from date of project Substantial Completion.

1.8 EXTRA MATERIALS

A. Exit Signs: The Electrical Contractor shall include as part of their scope of work to furnish and install additional exit signs above and beyond the number of devices shown on the plans at locations yet to be determined. This shall include the complete installation (conduit, boxes, wiring, labor, etc.). The locations shall be dictated during construction by the A/E, Owner and/or authority having jurisdiction. The quantity of additional exit signs shall be five (5) and the estimated length of conduit and wire required per location to connect to an adjacent exit sign circuit shall be fifty feet.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

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

B. LED Chips:

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

a. Cree
b. Nichia.
c. Samsung.
d. Sylvania.

C. Drivers:

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

a. Eldo LED.
b. Lutron.
c. Osram.
d. Phillips.
e. Sylvania.

f. Universal.

D. Emergency Power Control Device:

1. Eaton Lighting
2. Hubbell Lighting.
3. LVS, Inc.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. All fixtures shall be “Paint after Fabrication” (PAF).

B. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Fabricate lay-in fixtures of not less than #22 USG steel with 20 gage end plates, assembled with spot welds or concealed screw fasteners. All fixtures shall have no visible light leaks between the diffuser and the fixture housing.

E. Diffuser door frames shall be .050" extruded aluminum with mitered corners. Door frames shall be hinged by means of zinc plated "Tee" type hinges. The latching mechanism shall be visible and positive cam type. The door shall be gasketed to prevent dust accumulation. Door shall be the 1/2" deep regressed style.

F. Final Painted Enamel Finish: Similar and equal to Dupont "white" have a minimum reflection factor of 85 percent. Final finish shall cover all metal portions and be uniform in color, coverage, and gloss. Flat test samples shall withstand 300 hours of salt spray in accordance with ASTM B117-491.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

H. 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.
4. Laminated silver metallized film: 90 percent.

I. Plastic Diffusers, Covers, and Globes:

1. Acrylic lighting diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

a. Lens thickness: At least 0.125 inch minimum unless different thickness is indicated.
b. UV stabilized.

2.3 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC operation: LEDs, 70,000 hours minimum rated lamp life.

2.4 LED ASSEMBLY

A. LED luminaire manufacturer shall perform and provide documentation of a certified photometric report per IESNA LM-79. Shall be performed by an approved DOE Lab.

B. Provide IESNA LM-80 test data for each LED luminaire.

C. Minimum allowable CRI shall be 82.

D. Color temperature shall be: 3500K or 4000K.
1. A sample of each color temperature shall be provided to the owner for owner's decision on interior lighting color temperature.

E. Tunable white temperature range: 2700K – 6500K.

F. Rated life shall be minimum 60,000 hours at L70. Provide documentation.

G. Drivers: 0-10V dimming compatible with LED chip/module. Provide full range dimming down to 5 percent. Five percent shall be measured foot candle readings from full output readings.

2.5 EMERGENCY POWER CONTROL DEVICES

A. Operation: The EPC allows emergency lights to be switched or dimmed using the same controls as the normal (general) lighting in the same area. Upon loss of power, the EPC's will switch the emergency lights on at full brightness, regardless of switch or dimmer position, until normal power is restored.

B. The EPC shall be listed as a UL924 device.

C. Ratings:

1. Voltage: 120 or 277V Sensing Input, 60 Hz.
2. Temperature: 32 deg. F to 140 deg. F.
3. Load/capacity: 20Amps

D. The EPC shall include emergency power and regular power indicator LED's and a manual test switch which are visible to room occupants when installed flush.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "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 fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting Fixtures: Set level, plumb, and square with ceilings and walls. Install light fixtures flush with substrate.

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of two ceiling support system rods or wires for each fixture. Locate not more than 6 inches from lighting fixture corners.
2. Support clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application. The use of a bend out tab on the fixtures is not an acceptable clip. Clip shall be mechanically fastened to the fixture.
3. Fixtures of sizes less than ceiling grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:

1. Pendants and rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-mounted, single unit fixtures: Suspend with twin-stem hangers.
3. Continuous rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Adjust aimable lighting fixtures to provide required light intensities.

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

F. Generator Transfer Devices:

1. GTD serving individual fixture: Factory installed and mounted within the fixture. Shall be accessible from below the ceiling. If this is not possible, field install in an appropriately sized enclosure and mount above ceiling immediately adjacent to the fixture. Maintain clearance as required for maintenance.
2. GTD serving multiple fixtures: Field install in an appropriately sized enclosure and locate in east electrical room per each floor. Maintain clearance as required for maintenance.
3. Clearly and accurately mark locations of all GTD's on as-built drawings.
4. Provide normal, emergency and sensing circuit wiring per manufacturer's wiring diagrams.

G. Emergency Power Control:

1. EPC shall be mounted in a double gang box with an extension and a single gang plaster ring.
2. (1) EPC is required per switchleg/zone with emergency lighting and shall be located in the electrical room above the door.

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to generator power and retransfer to normal.

B. 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.

END OF SECTION 26 51 00

SECTION 26 56 00 - EXTERIOR LIGHTING

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. Exterior luminaires with lamps and ballasts.
2. Poles and accessories.

1.3 DEFINITIONS

A. CRI: Color-rendering index.

B. Luminaire: Complete lighting fixture, including ballast housing if provided.

C. Pole: Luminaire support structure, including tower used for large area illumination.

D. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports and supporting structure, applied as stated in AASHTO LTS-4.

B. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

1. Wind speed for calculating wind load for poles is 100 mph.

1.5 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.

4. Luminaire materials.
5. Energy efficiency data for luminate.
6. Lamps, including life, output, and energy-efficiency data.
7. Materials, dimensions, and finishes of poles.
8. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
9. Anchor bolts for poles.

B. Shop Drawings:

1. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
2. Wiring diagrams: Power and control wiring.

C. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 and that load imposed by luminaire has been included in design.

D. Qualification Data: For agencies providing photometric data for lighting fixtures.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

G. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

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. Comply with IEEE C2, "National Electrical Safety Code."

D. Comply with NFPA 70.

E. LED Lighting: Shall comply with or meet the requirements of IESNA LM-79 and LM-80.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty period for luminaires: Five (5) years from date of Substantial Completion.
2. Warranty period for metal corrosion: Five (5) years from date of Substantial Completion.
3. Warranty period for color retention: Five (5) years from date of Substantial Completion.
4. Warranty period for poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within five years from date of Substantial Completion.

B. Warranty for LED Products: Manufacturer’s standard form in which manufacturer agrees to repair or replace LED products that fail in materials or workmanship within specified period.

1. LED products: This shall apply to the entire LED product including, but not limited to, LED, LED modules, drivers, housing, lens, paint, etc. Replace items that fail and/or light output has decreased below the L70 values within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

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

2.2 LUMINAIRES, GENERAL REQUIREMENTS

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. 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.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. 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.

1. Surface preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," 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, "White Metal Blast Cleaning" or SSPC-SP 8, "Pickling."
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.

2.3 LED ASSEMBLY

A. LED luminaire manufacturer shall perform and provide documentation of a certified photometric report per IESNA LM-79. Shall be performed by an approved DOE Lab.

B. Provide IESNA LM-80 test data for each LED luminaire.

C. Minimum allowable CRI shall be 80.

D. Color temperature shall be within the following range: 4000K to 4200K.

E. Rated life shall be minimum 60,000 hours at L70. Provide documentation.

2.4 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.

B. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

C. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.

D. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor bolts, leveling nuts, bolt caps and washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
3. Anchor-bolt template: Plywood or steel.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."

F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.5 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.

1. Mounting provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.

2. Finish: Same as luminaire.

F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

2.6 POLE ACCESSORIES

A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.

1. Recessed, 12 inches above finished grade.
2. Nonmetallic polycarbonate plastic or reinforced fiberglass cover, that when mounted results in NEMA 250, Type 3R enclosure.
3. With cord opening.
4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

B. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following horizontal distances of poles from surface and underground features unless otherwise indicated on drawings.

1. Fire hydrants and storm drainage piping: 60 inches (1520 m).
2. Water, gas, electric, communication and sewer lines: 10 feet (3m).

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 3 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
3. Install base covers, unless otherwise indicated.
4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

F. Raise and set poles using web fabric slings (not chain or cable).

G. Install vibration damper per manufacturer’s recommendation.

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 Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole, unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

C. 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.

END OF SECTION 26 56 00

SECTION 27 05 00 - COMMON WORK RESULTS FOR COMMUNICATIONS

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. Section Includes:

1. Communications equipment coordination and installation.
2. Sleeves for pathways and cables.
3. Sleeve seals.
4. Grout.
5. Common communications installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of communications equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting pathways, cables, wire-ways, 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 communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 8 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section "Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum metal thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

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

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Hilti.
d. Metraflex Co.
e. Pipeline Seal and Insulator, Inc.
f. Specified Technologies, Inc.

2. Sealing elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
3. Pressure plates: Carbon steel. Include two for each sealing element.
4. Connecting bolts and nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS 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 communications 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 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Communications penetrations occur when pathways, cables, wire-ways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 3 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 7 Section "Joint Sealants".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 7 Section "Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Firestopping."

END OF SECTION 27 05 00

SECTION 27 05 26 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide the labor, tools, equipment, and materials necessary to furnish and install telecommunications grounding system in accordance with the plans and as specified herein. Provide all accessories as necessary for a complete system.

B. Provide communications system-grounding conductor at point of service entrance and connect to Telecommunications Main Grounding Busbar (TMGB). Bond together the communications system grounding.

C. This section includes the following:
1. Telecommunications Main Grounding Busbar (TMGB)
2. Telecommunications Bonding Conductor (TBC)

1.2 SUBMITTALS

A. Refer to and follow Submittals Sections 26 00 15

B. Product data for TMBG.

C. Ground resistance testing results certified by the testing organization.

D. Schematic diagram of the telecommunications grounding system.

1.3 QUALITY ASSURANCE

A. All equipment shall be UL listed and labeled for their intended usage.

B. All equipment shall comply with the latest National Electric Code.

C. All equipment shall comply with the latest TIA/EIA-607, and BICSI standards.

PART 2 - PRODUCTS

2.1 TELECOMMUNICATIONS MAIN GROUNDING BUSBAR (TMGB)

A. Provide Telecommunications Main Grounding Busbars (TMGB) as indicated on the drawings.

B. The TMGB shall have minimum dimensions of ¼-inch thick x 4-inch wide and 12-inch in length with 18 attachment points (two rows of 9 each). The length may need to be adjusted longer to meet the application requirements with consideration of future growth. The busbar shall be UL Listed as grounding and bonding equipment.

C. The TMGB shall be a predrilled solid copper busbar provided with standard NEMA bolt hole sizing and spacing for the type of connectors to be used. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 15 two-hole grounding lugs with 5/8" hole centers and 3 two-hole lugs with 1" hole centers. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4" standoff from the wall.

2.2 TELECOMMUNICATIONS BONDING CONDUCTOR (TBC)

A. Provide conductors used to bond components to the TMGB and the TGBs as follows:

1. Avoid unnecessary connections or splices in TBCs. When necessary, use an approved connection and position it in an accessible location.
2. Typical connections are made by using: bolts or crimps (connectors, clamps, or lugs). Where possible, use irreversible compression-type connections and two-hole lugs. Always use listed hardware that has been laboratory tested.

PART 3 - EXECUTION

3.1 INSTALLATION

A. As a minimum, Bond TMGB to following:

1. Building Steel (minimum #1/0 AWG insulated copper bonding conductor). Attach Bonding Conductors to Building Steel using listed exothermic welding process.
2. Main Electrical Service Ground (minimum #1/0 AWG insulated copper bonding conductor).
3. Local Service Panel Ground.
4. Telecommunications Bonding Backbone (TBB) that connects TMGB (minimum #1/0 AWG insulated copper bonding conductor).
5. Associated Telecommunications Cable Tray(s).
6. Telecommunications Conduit(s) Entering TR.

B. As a minimum, the Technology Contractor shall bond the following devices to the associated TMGB and TGBs using a minimum #6 AWG insulated copper bonding conductor using 2-hole compression style lugs:

1. PABX Equipment
2. Equipment Racks and Cabinets
3. TR Cable Ladder and Tray
4. CATV Equipment
5. Lightning and Surge Protectors
6. Telecommunications Devices

7. Coupled Bonding Conductors (CBCs)
8. Backbone Cable Shields
9. Telecommunication and Fiber Cable Shields
10. Antenna Cable Shields
11. Raised Floors

C. General:
1. Route ground conductors to provide the shortest, most direct path from point to point. Telecommunications ground must be bonded to the lightning protection system ground.
2. Bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, the conductors shall be bonded to each end of the conduit with a conductor sized as a #6 AWG, minimum (this makes the conduit a parallel path with the cable).
3. A continuous ground path shall be provided in all telecommunications raceways. Grounded cable trays shall be considered continuous ground path.
4. At each Telecommunication Room (TR) all equipment and raceways shall be bonded to the TGB.
5. Any grounding or bonding conductor that is run through a metallic conduit shall be bonded to the conduit.
6. Provide dedicated Telecommunications Bonding Backbone (TBB) to interconnect the TRs and related equipment.

D. Telecommunications Entrance Facility (TEF) Telecommunications Main Grounding Busbar (TMGB):
1. The Telecommunications Main Grounding Busbar (TMGB) serves as the dedicated extension of the building grounding electrode system for the telecommunications infrastructure. The TMGB also serves as the central attachment point for telecommunications bonding backbones (TBB) and equipment, and is located such that it is accessible to telecommunications personnel.
2. The TEF is the desirable location for the TMGB. This TMGB may serve as the TGB for collocated equipment in the TEF. The TMGB shall be bonded to electrical service equipment ground. This bond at the TMGB shall use a double bolted, compression style grounding lug. The bond at the electrical service equipment ground shall use an exothermically welded connection.
3. Where an electrical panelboard is located in the same room or space as the TMGB, the ground or enclosure of that electrical panelboard shall be bonded to the TMGB. Locate the TMGB as close to the electrical panelboard as practical to maintain clearances required by applicable electrical codes.
4. Locate the TMGB near the TBB cabling and associated terminations. The connections of the bonding conductors for telecommunications, and the TBBs to the TMGB shall utilize listed two-hole compression lugs.
5. Telecommunications primary protector grounding conductor shall be bonded to the TMGB. A minimum of 1 foot separation shall be maintained between this insulated conductor and any DC power cables, switchboard cables, or high frequency cables, even when placed in metal raceway.
6. All metallic raceways for telecommunications cabling located within Equipment Room (ER) shall be bonded to the TMGB. However for metallic raceways containing grounding conductors where the raceway is bonded to the ground conductor, no additional bonding to the TMGB is required.

7. In buildings where the backbone telecommunications cabling incorporates a shield or metallic member, this shield or metallic member shall be bonded to the TMGB where the cables are terminated or where pairs are broken out.

E. Telecommunications Room (TR) Telecommunications Grounding Busbar (TGB):
1. The TGB is the grounding connection point for telecommunications systems and equipment in the location served by that TR or ER. Each TR and ER shall contain a TGB. Multiple TGBs may be installed within the same TR or ER to aid in minimizing bonding conductor lengths and terminating space. In all cases, multiple TGBs within the same ER shall be bonded together with a conductor the same size as the TBB.
2. The TGB shall be located near the TBB cabling and associated terminations.
3. The bonding conductor between a TBB and TGB shall be continuous and routed in the shortest possible straight-line path. The bonding conductor shall be the same size as the TBB.
4. All metallic raceways for telecommunications cabling located within TR shall be bonded to the TGB. However for metallic raceways containing grounding conductors where the raceway is bonded to the ground conductor, no additional bonding to the TGB is required.
5. In buildings where the backbone telecommunications cabling incorporates a shield or metallic member, this shield or metallic member shall be bonded to the TGB where the cables are terminated or where pairs are broken out.

F. Telecommunications Bonding Backbone (TBB):
1. A TBB is a conductor that interconnects all TGBs with the TMGB. A TBB's basic function is to reduce or equalize potential differences between telecommunications systems bonded to it. A TBB is not intended to serve as the only conductor providing a ground fault current return path.
2. A TBB shall be designed with consideration given to the type of building construction, the telecommunications requirements, and the configuration of the telecommunications pathways and spaces. Specifically, the design of a TBB shall:
   a. Be consistent with the design of the telecommunications backbone cabling system.
   b. Address routing to minimize the lengths of the TBB.
3. All TBB Connections to be made with double-bolted, Compression style, Grounding Lugs.
4. TBB conductors shall be installed without splices. Where splices are required, they shall be kept to the minimum quantity necessary, shall be accessible and located in telecommunications spaces. Joined segments of a TBB shall be connected using irreversible compression-type connectors or exothermic welding. All joints shall be adequately supported and protected from damage.

G. Telecommunications Bonding Conductors (TBC):

1. Bonding conductor sizing. The following applies to the Telecommunications Bonding Conductor (TBC):
   a. Bonding Conductor Length (ft) / Bonding Conductor Size (AWG)
      1) <13 / #6
      2) 14-20 / #4
      3) 21-26 / #3
      4) 27-33 / #2
      5) 34-41 / #1

6) 42-52 / #1/0

SECTION 27 05 28 PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install all conduits, cable trays, outlet boxes, raceways, risers, service lateral conduits and backboards for a complete pathway for communications systems as specified herein and as shown on the drawings.

B. Rooms with lay-in ceiling shall have conduit stub-up to 1” above accessible ceiling. In all other rooms, provide conduit continuously routed to nearest cable tray or support structure in corridor with lay-in ceiling or directly to telecommunications equipment.

C. Unless noted otherwise, refer to Division 26 Specifications for requirements for conduits, outlet boxes and raceways.

D. Furnish and install cable tray system as specified herein and as shown on the drawings.

1.2 SUBMITTALS

A. Manufacturer’s product data sheets including dimensions, materials and finishes.

B. Coordination drawings with scaled floor plans including cable tray system layout relative to adjacent elements of other trades as coordinated in the field.

1.3 QUALITY ASSURANCE

A. All communications pathway equipment shall be UL classified and labeled and comply with latest NEMA, ASTM and ANSI Standards.

B. In addition, cable tray systems shall comply with the latest NEC Article 392, NEMA VE-1 and VE-2, and TIA 569-B.

C. Cable tray system of any type shall be from the same manufacturer.

1.4 COORDINATION

A. Coordinate layout and installation of cable tray with other trades installations.
   1. Any revision of locations and elevations from those indicated as required to suit field conditions will require A/E approval in writing.

1.5 DELIVERY, HANDLING AND STORAGE

A. Storage and Handling: Avoid breakage, denting and scoring finishes. Damaged products will not be installed. Store cable trays and accessories in original cartons and in clean dry space; protect from weather and construction traffic. Wet materials will be unpacked and dried before storage.

B. Equipment or materials damaged during storage or installations shall be replaced as directed by the A/E at Contractor's cost.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Wire Mesh and Ladder Cable Tray
   1. Cablofil
   2. B-Line
   3. Thomas & Betts
   4. Chalfant
   5. Chatsworth
   6. Snake Tray

2.2 WIRE MESH CABLE TRAY

A. Wire mesh tray system includes (but not limited to) straight sections, horizontal and vertical bends, tees, dropouts, supports and accessories.

B. Mesh tray shall be electro-plated zinc galvanized steel, continuous, rigid, 2" x 4" grid and spot welded wire at all intersections.

C. Tray width shall be as shown on drawings. Tray height shall be such that usable cable loading height is 4".

D. Straight sections of tray shall have continuous top wire safety edge and welded to all tray sides. Provided in 10' sections.

E. Mesh tray shall be support at a maximum of 5' intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Cable tray and J-hook systems shall be installed level and plumb according to manufacturer's `written instructions, coordination drawings and applicable standards.

B. Cable trays are strictly for telecommunications cabling only. Other cables such as power, fire alarm, security, low voltage controls, etc. are not permitted in cable trays.

C. Cable trays shall be assembled with bolted splice plates. Splice hardware shall be zinc plated.

D. Install necessary expansion splice hardware at locations as recommended by manufacturer and as shown on the drawings.

E. Ground and bond metallic cable trays in accordance with NEC Article 392.7:
   1. Provide bonding to maintain continuity between all cable tray components.
   2. Bond cable tray sections at maximum 100' intervals with minimum #6 AWG bare copper conductors to building steel or telecommunications grounding bars.
   3. Make connections to cable tray with compression connectors.
   4. Cable tray shall not be used for equipment grounding means.
   5. Refer to Section "Grounding and Bonding for Telecommunications Systems" for additional requirements.

F. Secure conduits attached to cable trays with approved clamps. Install grounding bushing on conduit end and extend #12 AWG bonding jumper to cable tray.

G. Cable tray shall penetrate walls through wall sleeves. Wall sleeves shall be galvanized steel, have height and width matching cable tray. Install wall sleeves with approved firestopping when penetrating fire-rated walls, matching fire rating of wall being penetrated.

H. Conduits extensions to cable trays shall be within 6" of tray.

I. Hung cable tray shall be supported from building structure with trapeze type hanger, threaded rods and accessories as recommended by the manufacturer.

J. Cable trays installed adjacent to walls shall be supported with wall brackets and accessories as recommended by the manufacturer.

K. Unless noted otherwise, cable tray located above lay-in ceiling shall be installed below HVAC and piping system.

L. Cable trays shall be located no less than 12" from power cabling or luminaire ballasts.

3.2 FIELD QUALITY CONTROL

A. Test electrical continuity cable tray systems grounding and bonding connections for compliance with maximum grounding resistance specified.

END OF SECTION 27 05 28

SECTION 28 05 00

COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes general requirements for Division 28 work and is supplemental and in addition to the requirements of Division 1.

B. It is the intention of this Division of the Specifications to describe and provide for the furnishing, installing, testing and placing in satisfactory and fully operational condition all equipment, materials and devices necessary to provide a complete Division 28 system.

C. The Division 28 Security Systems shall be bid to the Detention Equipment Contractor as a complete package. Delineation of responsibilities between the Division 11, 26 and 28 contractors are specified herein.

D. The Steel Detention Cell shall include a factory installed self-contained modular control system (MCS) that controls and monitors the cell door and intercom. The system shall utilize Ethernet to distribute control and monitoring commands between the Security System Integrator's (SSI's) security network and touch screen application and the factory installed MCS. Omron shall be acceptable PLC manufacturers for this solution. The Steel Detention Cell manufacturer shall also provide a Modular Control Interface (MCI) server to be located in the primary security equipment room. The MCI will receive and transmit commands from the System Integrator's SCADA software, PLC system and audio system. In addition, the MCI server will distribute 24VDC power, audio commands, audio paths and control commands to the MCS as required to provide a fully functional system.

E. The Division 28 Security Systems Integrator (SSI) shall be responsible for the coordination, furnishing and installation of all Division 28 systems, which shall include the following:

1. 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY & SECURITY
2. 280510 – CABINETS AND ENCLOSURES
3. 281300 – ACCESS CONTROL SYSTEM
4. 282300 – IP VIDEO COMMUNICATION SYSTEM
5. 284619 – SECURITY AUTOMATION SYSTEM
6. 284620 – VIDEO GRAPHIC USER INTERFACE
7. 285123 – IP AUDIO COMMUNICATION SYSTEM

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F. This project includes a new pod addition and a remodel/addition of the existing Intake/Booking, Kitchen, and Administration areas.

G. The Division 26 contractor shall design, furnish, install and place in satisfactory condition all conduits/raceways, boxes (back boxes and junction boxes), conductors and connections and all other materials required for the Division 28 systems specified in the contract documents to be complete and fully operational upon completion of the project.

H. The Division 26 contractor shall provide new network cabling for existing analog camera locations being replaced with network cameras.

I. All cabling provided by the Division 26 contractor shall be in conduit where determined, and continuous between the field device and the head-end equipment location. The Division 26 contractor shall maintain uniform phasing and color-coding throughout system, adhering to the approved Division 28 shop drawings.

J. The SSI shall coordinate with the Division 26 contractor all requirements of the security electronics cable system including PLC/GUI, video surveillance, access control, audio communications, and other miscellaneous systems per NEC, as shown in the project documents.

K. The Division 26 contractor shall set in place all SSI-supplied security equipment cabinets, racks and enclosures. The SSI shall provide documentation detailing the required installation.

L. The Division 26 contractor shall be responsible for the provision and installation/terminations of all required 120VAC power, including UPS circuits, for the security electronics head-end equipment and control station location equipment.

M. The Division 26 contractor shall be responsible for all cabling/conduit coordination in regard to electric locks, position switches, door hardware and door frames supplied by Division 8 and/or Division 11 contractor(s).

N. The Division 26 contractor shall be responsible for all Division 28 field device and head-end equipment installation and terminations. The Division 26 contractor shall be responsible for the demolition of existing security electronics control system equipment. The SSI shall be responsible for the installation and terminations of all control station equipment, including GUI PCs, monitors, network client PCs and monitors.

O. The General Contractor shall provide coordination to ensure that control rooms and rooms housing security electronics head end equipment are completed, clean and have conditioned air as early as possible to facilitate completion of control wiring and terminations. Space shall be free of air-borne particles prior to installation of any Security Electronics Equipment. The Architect shall inspect and approve the condition of these rooms prior to the installation of any active equipment.

P. The Division 11 contractor shall furnish and install all security hardware, adjust all door position and lock position switches as necessary to properly indicate to the security electronics system, provide all hardware and frame schedules as necessary to pertinent contractors, and provide all wiring diagrams to the SSI and Division 26 contractors for electric locking devices being interfaced to by the security electronics system.

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Q. The Owner shall be responsible for providing a high-speed internet connection to the Security Management System for remote diagnostics by the SSI. The Owner shall provide a network connection between their LAN and the video management system. Configuration of the Owner's network switches shall be by the Owner. Inmate Telephone system terminations at the SSI-supplied telephone relay interface panel shall be by the Owner's telephone system contractor.

1.3 DEFINITIONS

A. UL: Underwriters Laboratories

B. NEMA: National Electrical Manufacturer's Association

C. NEC: National Electrical Code

D. NFPA: National Fire Protection Association

E. SSI: Security System Integrator

1.4 SUBMITTALS

A. General: Submit the following information to be included in the submittal package.

B. Product Data:
1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Indicate specification section and paragraph for each item.
3. Indicate listing by UL or other approved testing agency.
4. Data sheets showing multiple products or models shall clearly identify the specific product or model being proposed.
5. Submit in a three-ring binder with hardboard covers.

C. Shop Drawings: Submitted shop drawings shall be generated utilizing AutoCAD and shall be drawn to the drawing/detail scale. The Electronic Safety and Security shop drawings shall include, but not be limited to the following:

1. Dimensions, weights, loads, required clearances, method of field assembly, location and size of each field connection.
2. Detailed equipment enclosure drawings showing arrangement of all proposed equipment with required wire-way and receptacles shown.
3. System risers showing all required interconnections for the following subsystems along with any special terminations that may be required for that subsystem:

    a. Overall Electronic Safety and Security System
    b. PLC I/O Network
    c. Ethernet Network
    d. Video Surveillance System
    e. Digital Intercom System
    f. Utility & Misc. Systems

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4. Submit power system drawings indicating all fuse ID numbers as well as voltage and size.
5. Submit power loading spreadsheets detailing all AC power circuits and DC power supply circuits. The spreadsheet shall indicate each device's steady state and in rush current requirements.
6. Submit device schedules that reference the shop drawings detailing exact termination locations for each security device in the system. The device schedules shall indicate the name, location, termination point, voltage, and fuse ID for each. The schedules shall be categorized by device type (i.e. doors, intercoms, cameras, proximity readers, etc.).

D. Operation and Maintenance Data: Provide O&M manuals as required below:

E. The O&M manuals shall include the information required to operate and maintain all Division 28 electronic security system equipment. The information provided shall include the following:

1. Operations manual for GUI and Security Management System.
2. As-built shop drawings, including up-to-date device schedules.
3. Wiring diagrams.
4. CD with manufacturer's installation and operations manuals.
5. Complete list of spare parts being provided.
6. The current contact (including service) information for the SSI.
7. Provide two (2) copies of each operating and maintenance manual. Manuals shall be bound in "D-ring" binders with a detailed table of contents.
8. Provide one electronic copy of the O&M manual for inclusion with the O&M manual deliverables on a USB flash drive.

F. Software Deliverables: Provide a software binder that shall incorporate the following files and information;

1. Provide a text file containing all operator and administrator-level passwords for the GUI system, Security Management system, digital intercom system, PLC system and DVMS.
2. PC recovery files, GUI runtime licenses, digital intercom system software, VMS software, PLC software, and monitor drivers.

1.5 QUALITY ASSURANCE

A. Security Systems Integrators

1. Only PRE-QUALIFIED Security System Integrators (SSIs) shall be permitted to bid on the Division 28 Electronic Security Systems.
2. The pre-qualified SSIs shall only be allowed to furnish materials from the manufacturers as specified in the Division 28 specifications.
3. The SSI shall assume sole-source responsibility for the entire electronic security system and shall not subcontract out any programming work associated with the GUI or PLC systems. The SSI shall ensure that all integrated systems are compatible with each other for a complete, fully operational and fully tested system upon completion of the project.
4. The SSI shall furnish and install only new material, unused without any defects.
5. The following pre-qualified Security System Integrators (SSI's) shall be allowed to submit pricing:

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a. Security Automation Systems, Inc. (Indianapolis, IN) (Basis of Design)
b. Accurate Control, Inc. (Ripon, WI)
c. Stanley Convergent Security Systems (Fishers, IN)

B. Approval for additional Security System Integrators

1. Approval of an SSI does not include acceptance or products or procedures, unless approved by the Architect.
2. All SSI's must adhere to the materials, intent, and design specified herein.
3. Firms desiring to bid the Division 28 specifications as an SSI must submit, at least 10 days prior to the bid, a pre-qualification package that includes the following information:
   a. AIA-305A Contractor Qualification Statement.
   b. A letter from the SSI's surety company reflecting the surety company's history and experience with the SSI and the current bonding limit for the last 5 years.
   c. Organizational chart and resumes of key individuals.
   d. Company's history of providing security electronic control systems for correctional facilities.
   e. Provide a list of at least 5 other projects in Indiana similar in size and scope to this project (utilizing programmable logic controllers) completed in the last 5 years. For each project list the major subsystems with manufacturers used and the total dollar amount of the project. The current end-user contact (name, address and phone number) shall be listed for each project.
   f. List the names and up-to-date phone numbers of the Architect, System Engineer and Owner of ALL Jail/Detention/Corrections projects installed by the submitting SSI within the last 5 years.
   g. Provide a narrative description of all software to be utilized, network types, and interfaces with other systems. Any custom software that is to be developed by the SSI shall be described in detail.
   h. An explanation of the company's ability to provide service to the Owner and the location and proximity of the company's physical service organization location.
   i. Provide evidence that the company has a physical service organization located within 2 hour's drive time of project site.
4. Firms approved as SSIs shall submit their pricing according to the Division 01 bidding documents.

C. Where the SSI is a branch office or other division of a larger organization, the qualifications of the branch office or other division shall meet the requirements of the Contract Documents.

D. SSIs that do not meet the listed requirements, or in the Owner's, Architect's (if applicable) or Engineer's (if applicable) judgement do not have a reputation of acceptable service or satisfactory performance levels on completed projects, shall be disqualified from bidding.

E. All work shall conform to the applicable code provisions of the NEC and NFPA (as adopted and amended by the Local Jurisdiction).

1.6 COORDINATION

A. Coordinate the work of this section to meet the substantial completion date.

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B. Coordinate the delivery and location of items with the Construction Manager.

C. Special attention is called to the following items. Coordinate all conflicts prior to installation:

1. Location of millwork, control consoles, counters, desks, doors and frames so that Division 28 material is in proper relation to these items.
2. Scheduling of new equipment for installation.

D. The SSI shall coordinate their security equipment rack space requirements with the Owner in shared spaces.

1.7 DELIVERY, STORAGE, AND HANDLING

A. SSI shall mark or tag each relevant item of equipment (cameras, housings, monitors, etc.) for the project. The SSI shall deliver equipment at the proper time and location for installation. Equipment received, but not installed shall be placed in secured storage. Handling shall be controlled to prevent losses and delays. Upon delivery, the SSI shall inspect equipment for damage. All damaged items shall be removed from the site and replaced.

B. For equipment stored off-site, the SSI shall protect equipment from theft or damage. All items stored for the project shall be clearly labeled as such and shall be available for inspection. Shipping receipts for stored items shall be made available upon request. The SSI shall provide appropriate insurance coverage for stored equipment that shall cover all items against theft or damage.

1.8 WARRANTY

A. The SSI shall warrant all material and workmanship for Division 28 systems for a period of twelve (12) months after substantial completion (see ADJUSTING, section 3.5). The warranty shall cover all material and software provided. The SSI shall provide qualified and/or manufacturer-certified technicians capable of diagnosing and repairing the installed system.

B. The SSI shall repair or replace (at no cost to the Owner) any defective materials or work when given written notice during the warranty period. Warranty service shall be provided to the Owner during normal working hours. When requested by the Owner, after-hours service (including on-site service) shall be provided and the SSI's applicable labor and travel rates shall apply.

C. The SSI shall provide emergency service during the 12-month warranty period. The SSI shall provide the owner a 4-hour phone response time and a one business-day response time for major system failures. Major system failures shall be considered those failures which result in limited or no functionality of major electronic security system components, such as a PLC failure or a GUI failure.

D. The warranty shall exclude acts of vandalism, abuse, neglect, Owner misuse, failure of the Owner to provide continuous environmental conditions for which the installed equipment is rated for, and all other acts beyond the control of the SSI (i.e. – weather damage, floods, fire, lightning, and similar acts).

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1.9 EXTRA MATERIALS

A. The SSI shall reference each specific section in Division 28 for extra materials required. Extra materials shall match products installed and shall be packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect the conditions under which Work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances.

C. Comply with manufacturer's installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

D. Precautions shall be taken to guard against electrostatic and electromagnetic susceptibility and interference.

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

3.2 INSTALLATION

A. Provide complete electronic security system as specified herein.

B. All system equipment to be contained within equipment racks or cabinets. If more or larger equipment racks or cabinets are required than exist or are indicated on the drawings, allow for such additional equipment racks and cabinets in contract price.

C. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

D. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

E. All cable within equipment racks, cabinets, or on backboards, to be neatly bundled and secured.

F. Wires shall not be nicked, have strands removed, or have frayed strands when removing insulation or terminating.

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G. Factory manufactured interface cables to be provided for each field interface board. Terminal blocks to be provided in cabinet or on backboard for factory cable interface to field wiring.

H. Provide adequate ventilation for all heat radiating equipment. SSI shall provide fan kits as required to maintain rated operating temperature of installed equipment.

I. Seal-tite flexible conduits, NEMA-rated weatherproof junction boxes connectors shall be utilized for exterior camera locations.

3.3 CONNECTIONS

A. For equipment furnished under this Division of the specifications, provide all Division 28 connections necessary so that the equipment is fully operational upon completion of the project.

B. Ground equipment according to manufacturer’s recommendations.

3.4 FIELD QUALITY CONTROL

A. Verify that the electronic security system work is installed according to the Contract Documents. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents. Perform additional inspections to determine compliance of replaced or additional work.

B. Manufacturer's Field Service: The SSI shall provide a qualified technician and/or factory-authorized service representative to inspect, test, and adjust security electronic security system components and equipment installation, including connections, and to assist in field testing.

C. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After the security electronic system has been energized, perform an operational test of the system to verify compliance with the Contract Documents.
2. When test results indicate that electronic security work does not comply with the Contract Documents, the SSI shall diagnose and correct the deficiencies.
3. Retesting: At the SSI’s expense, test and adjust electronic security system head-end equipment and field devices. Replace damaged and malfunctioning equipment.

D. Remove and replace malfunctioning equipment and retest as specified above.

3.5 ADJUSTING/SCHEDULED MAINTENANCE

A. SSI shall provide initial electronic security system configuration and adjustments. All field devices and head-end equipment shall be adjusted for optimum performance.

B. Occupancy Adjustments: The SSI shall provide two (2) scheduled, on-site preventative maintenance/adjustment visits during the warranty period. During these visits, the SSI shall make any necessary adjustments to the electronic security system and replace/repair any defective equipment and/or workmanship found. The duration of each visit shall be a minimum of 4 hours. Each visit shall be documented in a maintenance log and shall be presented to the Owner.

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3.6 SYSTEM TESTING

A. Prior to the shipment of the PLC and GUI control systems to the project site, the SSI shall provide a full system test of all security electronic control system equipment. All control system hardware head-end equipment, including all PLC input and output points, shall be tested with the GUI software and Security Management system. The SSI shall make all necessary software modifications/corrections based on the results of the testing. The control systems shall be re-tested after the software modifications/corrections have been made.

B. At a minimum of 30 days prior to the shipment of the control system equipment to the project site, the SSI shall notify the Owner that the control system equipment is tested and ready to be demonstrated. This demonstration shall be conducted at the site of the SSI. During the demonstration, the SSI shall coordinate with the Owner to make any programming/configuration changes to the system. These changes may include minor changes to the layout and text on the GUI screens, based on the operational requirements of the Owner.

3.7 DEMONSTRATION

A. Provide qualified and/or manufacturer-certified personnel to train Owner's maintenance personnel to adjust, operate, and maintain the electronic security system. Refer to Division 01 Section “Demonstration and Training”.

B. Provide demonstration and instruction sessions to familiarize Owner’s operation and maintenance personnel with systems and their operation and maintenance.

C. Establish agendas for demonstration and instruction sessions in conjunction with the Architect and Owner. Coordinate scheduling of sessions with the Architect and Owner.

D. Provide two 8-hour seminars to demonstrate operation of the systems.

E. Provide two 8-hour technical seminars to demonstrate configuration, troubleshooting, repair and maintenance of the system.

F. Training shall be video recorded.

END OF SECTION 28 05 00

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SECTION 28 05 10

CABINETS AND ENCLOSURES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 and Division 28 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This project includes utilizing existing Security Equipment Enclosures and Door Relay Cabinets. Refer to the drawings and specifications for existing equipment locations.

B. This Section includes the requirements for Cabinets and Enclosures for the Electronic Safety and Security system. The cabinets and enclosures shall contain all Electronic Security System head-end equipment.

C. The Cabinets and Enclosures for the Electronic Safety and Security system shall include the following main components:

1. Security Equipment Enclosures:

    a. Free-Standing Security Equipment Enclosures.

    b. Wall-mounted NEMA 12 enclosures for utility control.

    c. Site-located gate control equipment system enclosure.

2. Control Console:

    a. Custom Control Console located in Control Room D200

1.3 DEFINITIONS

A. AWG: American Wire Gauge

B. NEMA: National Electrical Manufacturers Association

C. SSI: Security Systems Integrator

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1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: Detail equipment enclosure assemblies and indicate dimensions, loads, required clearances, and required components.

1. Wiring Diagrams: Power, signal, and control wiring.
2. SSI shall provide complete enclosure design showing the layout of all devices housed within the enclosures.

C. Operation and Maintenance Data: For Cabinets and Enclosures for Electronic Safety and Security system to include in operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

1.6 COORDINATION

A. Coordinate layout and installation of the Cabinets and Enclosure for the Electronic Safety and Security system equipment with existing conditions that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.7 WARRANTY

1. Warranty Period: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SECURITY EQUIPMENT ENCLOSURES

A. Manufacturers:

1. Middle Atlantic
2. Hoffman

B. Description: This specification describes the Security Equipment Enclosures used for housing Electronic Security System devices. The free-standing enclosures shall house at a minimum, PLC processor equipment, video surveillance head-end, digital intercom head-end, relays, power supplies, network switches and access control equipment. The wall-mounted NEMA 12 enclosures shall house PLC output modules and lighting/receptacle/telephone control relays. The site-located gate control equipment enclosure shall house power supplies, network switches and fiber optic transceivers. SSI shall refer to bid prints for Security Equipment Enclosure locations.

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C. Free-Standing Security Equipment Enclosure

1. Provide freestanding equipment cabinets to house 19" rack mountable equipment in the equipment rooms. Each cabinet shall have a rectangular frame with removable side panels and doors. Tops shall accept additional cooling fans if required. Installed cabinets shall include thermal, power, and cable management accessories that control airflow through the cabinet and keep signal and power cables separate and organized.
2. Enclosure shall be vented and provide fan units, as necessary, per the manufacturer's recommendations and actual heat loads of the installed equipment.
3. Enclosure shall be rated for a minimum 2500lb UL listed load capacity.
4. Shall be constructed using 14 or 16-gauge steel tops & bottoms and minimum 16-gauge steel frame construction.
5. Provide fully perforated front and rear doors with keyed locks and provide side panels on each end of consecutive modular enclosures.
6. The depth of each enclosure shall accommodate all equipment mounted within. Enclosure shall include a minimum 30-5/8" usable depth. Equipment hindering the closing and locking of any enclosure door will not be acceptable.
7. Enclosure shall include 24-1/4" OD width for cables, 2 extra-wide pair of 10-32 threaded rack rail. Enclosure shall include laser-cut 1/8" thick internal braces for strength.
8. Enclosure shall be finished in a durable black textured power coat.
9. Provide multi-outlet plug strips along the inside of the enclosure as required.
10. Wiring within the enclosure shall be routed within covered wire ways.
11. Enclosure shall have grounding stud installed in base.
12. Approved manufacturers: Middle Atlantic (WRK series) and Hoffman

D. Wall-mounted NEMA 12 enclosure

1. Shall be constructed of 14AWG rolled steel and be NEMA 12 rated.
2. The enclosure shall have a removable 12AWG inner panel for equipment mounting.
3. Door bar on hinge side for wire management and bonding.
4. Mounting holes in back of body for direct mounting or for optional external wall-mounting brackets.
5. Seamless foam-in-place gasket shall provide oil-tight and dust-tight seal against contaminants.
6. Provision for thermoplastic data pocket.
7. Approved manufacturers: Hoffman, Hammond

E. Site-located Gate Control Equipment System Enclosure

1. Shall be constructed of 14AWG Type 304 stainless steel and be NEMA 4X rated.
2. The enclosure shall have a removable 12AWG inner panel for equipment mounting.
3. The enclosure door shall include a padlock adapter for use with a padlock. Door hardware supplier shall provide a padlock for the enclosure door.
4. Approved manufacturers: Hoffman and Hammond

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2.2 CONTROL CONSOLES

A. Manufacturers:

1. Xybix (www.xybix.com)

2. Evans

B. Description: This specification describes the new Control Console that shall be located at Control Room D200. At Control Room D200 the SSI shall provide and install one 78" x 78" Dual Surface Control Console with true sit to stand adjustable range of 22" – 48" AFF, with L5 Table Base. This control console shall be used to house GUI PCs and other associated equipment. They shall be used as working platforms for GUI control, CCTV monitors, audio communication devices and other Owner-provided equipment. The basis of design is Xybix.

C. Control Console

1. The Control Console shall consist of the following features;
   a. Xybix 78" x 78" Dual Surface Console with true sit to stand adjustment range of 22" – 48" AFF, with L5 Table Base.
   b. Under fixed work surface, drawer pedestal 18"W with 6", 6" and 12" drawers.
   c. "Rollervision" Monitor Mounting System with 10" of focal depth adjustment. System shall accommodate (2) 27" and (1) 32" flat panel monitors on a single level. Addition mounts shall be added to stack a second tier of (2) 27" flat panel monitors.
   d. Single shelf with grommet, under monitor surface, 19"W x 5 ¼"H x 9"D with Power-Only USB ports
   e. Data Dock – Keyboard surface cable organizer with (8) USB Ports and (1) CAT6 port.
   f. (2) Dimmable Lux task lights with a flexible mounting arm, mounted to keyboard surface.
   g. Swivel Cup Holder.
   h. Cable Management Bridge for cable organization from desk to CPU cabinet
   i. (5) CPU Enclosure, 39.25" wide, under flip top work surface with front locking access doors, fixed shelf and (2) silent 45 CFM fans for active ventilation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect both the substrate and conditions under which work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. SSI shall coordinate with the Owner to confirm that no obstructions exist that would hinder the installation of the required Cabinets and Enclosures.

C. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances. SSI shall

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coordinate with the Owner to confirm that no obstructions exist that would obstruct the installation.

D. Comply with manufacturer’s installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

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

3.2 INSTALLATION

A. Provide Cabinets and Enclosures for the Safety and Security system as specified herein.

B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

C. All system equipment to be contained within equipment racks, cabinets, or closets. If more or larger equipment racks or cabinets are required than exist or are indicated in the specifications, allow for such additional equipment racks and cabinets in contract price.

D. Provide adequate ventilation for all heat radiating equipment.

E. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

3.3 CONNECTIONS

A. Ground equipment according to manufacturer’s recommendations.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect and verify the Cabinets and Enclosures for the Electronic Safety and Security system components and equipment installation, including connections, and to assist in field testing.

3.5 ADJUSTING

A. SSI shall ensure that all cabinet and enclosure doors and locks are operating properly and that no obstructions exist. Make proper adjustments as necessary.

3.6 DEMONSTRATION

A. Provide qualified personnel to train Owner's maintenance personnel to adjust, operate, and maintain the Cabinets and Enclosures for the Electronic Safety and Security system. Refer to Division 01 Section "Demonstration and Training."

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B. Training shall be video recorded.

END OF SECTION 28 05 10

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SECTION 28 13 00

ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 and Division 28 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The existing Hirsch access control system shall be removed and disposed of. The existing Hirsch scramblepad readers and additional stand-alone keypad readers shall be removed and disposed of, or replaced with new equipment as shown on the plans.

B. The SSI shall provide an access control system as specified herein. The system shall include all equipment, installation, installation materials, set up, and testing to form a complete operating system. Independent system functions shall be fully verified as part of system testing and commissioning.

C. For those doors that are connected to the PLC door control and GUI control station system, the access control system shall provide a dry contact interface between the node(s) and the PLC system. The access control system shall make requests (outputs) to the PLC system (PLC inputs) to open the doors upon a successful read by a reader of a valid credential.

D. The SSI shall provide initial configuration of the access control system, confirming all network nodes are operational and properly configured with the controller. The SSI shall confirm all inputs, outputs and readers are properly configured for each node and portal, and that the interface with the PLC system has been configured and verified for each portal.

E. The SSI shall demonstrate and provide training to the Owner on the methods and procedures for enrolling people into the access system database. This shall include instruction on entering personal information for each individual, credential information and configuring access levels, permissions, etc. The Owner shall be responsible for enrolling their staff and additional people into the system.

F. The Owner shall be responsible for configuring access levels, access level groups, custom schedules, etc. for people in the system. If, during the warranty period, the Owner requires technical assistance from the SSI for system configuration changes, this work would be considered outside the scope of the SSI's responsibilities and the SSI shall offer a cost proposal for the requested changes.

G. The access control system network controller shall be connected to the facility LAN. The SSI shall coordinate the configuration of the network controller and network nodes as required with the Owner's IT facility administrator. The Division 26 contractor shall provide and install all necessary data cabling to connect the network controller to the facility LAN.

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H. The access control system shall be implemented through network appliance architecture with a three-tiered modular hardware hierarchy and embedded three-tier software architecture.

1. The network appliance shall be capable of running on a TCP/IP network and shall be accessible, configurable, and manageable from any network-connected PC with a browser.
2. Browser access for configuration and administration of the system shall be possible from a PC on the same subnet, through routers and gateways from other subnets, and from the Internet. Control and management of the system shall therefore be geographically independent.
3. Security of the data communicated over the network to and from the browser, network controller, and nodes is protected by encryption (SSL 128-bit) and authentication (SHA-1).
4. The top hardware tier is the network controller. Embedded on the Network Controller are an operating system, a web server, security application software, and the database of personnel and system activity.
5. The middle hardware tier is the network node. The network node shall make and manage access control decisions with data provided by the network controller, and it shall manage the communication between the network controller and Application blades connected to the system's inputs, outputs, and readers. This modular design makes it possible, even during network downtime, for the system to continue to manage access control and store system activity logs. When network connectivity is re-established, the system activity logs are automatically re-integrated.
6. The bottom hardware tier is the Application Blades. Four unique Application blades shall be available:

    a. Access Control Blade: shall support two readers, four supervised inputs, and four relay outputs.
    b. Alarm Input Blade: shall support eight supervised inputs.
    c. Relay Output Blade: shall support eight relay outputs.
    d. Temperature Blade: shall support eight analog temperature sensor inputs.

I. The access control system shall integrate, within a browser interface, access control, alarm monitoring, video monitoring, and temperature monitoring applications. These applications shall be embedded in a three-tier software architecture.

1. The database tier shall use PostgreSQL. PostgreSQL is a full featured, high performance database management system that supports ODBC. This shall provide a small footprint, low administration, and high reliability relational database that is embedded without requiring the use of a separate PC server.
2. The web server tier shall be based on an Apache™ embedded web server. This shall provide a graphically rich security management application through a standard web browser.
3. The security application software tier contains the business logic. This application shall also be embedded on the network device and requires no additional memory or processing power.
4. This three-tiered embedded software design runs within an embedded Linux Ubuntu operating system and shall require no client-side software other than a web browser.

J. Client-server based access control systems that require the access control software to be installed on a PC or server-type machine shall NOT be approved.

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K. Systems that utilize serial-based proximity readers with Ethernet-serial converters shall NOT be approved.

L. All equipment and materials used shall be standard components, regularly manufactured, and regularly utilized in the manufacturer's system.

M. All access control systems and components shall have been thoroughly tested and proven in actual use.

N. All access control systems and components shall be provided with an explicit manufacturer warranty of one year for software and two years for hardware.

O. The access control system shall include the following main components:

1. Network Controllers
2. Network Nodes
3. Access Control Blades
4. Access Management Software
5. iCLASS SE Readers
6. iCLASS SE Key Fobs
7. Request-to-exit motion detector
8. Optical Weigand Data Extender

P. Related Sections:

1. Division 08 Section – "Door Hardware".

Q. Codes and References: Comply with the current version year adopted by the Authority Having Jurisdiction.

1. ANSI A117.1 - Accessible and Usable Buildings and Facilities.
2. ICC/IBC - International Building Code.
3. NFPA 70 - National Electrical Code.
4. NFPA 80 - Fire Doors and Windows.
5. NFPA 101 - Life Safety Code.
6. NFPA 105 - Installation of Smoke Door Assemblies.
7. State Building Codes, Local Amendments.

1.3 DEFINITIONS

A. AJAX: Asynchronous Javascript™ and XML technology

B. NAS: Network attached storage

C. FTP: File transfer protocol

D. SSI: Security Systems Integrator

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1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and accessories.

B. System Operational Descriptions: Complete system operational narratives for the integrated access controlled openings defining the owner's prescribed requirements for the opening functionality. Narratives include, but are not limited to, the following situations: normal secured/unsecured state of door; authorized access; authorized egress; unauthorized access; unauthorized egress; fire alarm and loss of power conditions, and interfaces with other building control systems.

C. Shop Drawings: Detail equipment enclosure assemblies and indicate dimensions, loads, required clearances, components, and location of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

a. Elevation diagram of each unique access controlled opening showing location and interconnection of major system components with respect to their placement in the respective door openings.

D. Coordination Drawings: Details, drawn to scale, on which the following items are shown and coordinated with each other:

1. Readers
2. Network Switches
3. Network Controllers
4. Network Nodes

E. Proof of Certification: Provide copy of manufacturer(s) official certification or accreditation document indicating proof of status as a qualified and authorized provider of the primary access control components.

F. Operation and Maintenance Data: For access control system to include in operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Schedules detailing locations, titles, and termination locations of all readers, network controllers and network nodes.

1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

B. The SSI shall be an authorized integrator of the access control system.

C. The installed access control system shall conform to all local jurisdiction requirements.

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1.6 COORDINATION

A. Coordinate quantity and arrangement of assemblies with ceiling space configuration and with components occupying ceiling space, including structural members, pipes, air-distribution components, raceways, cable trays, recessed lighting fixtures, and other items.

1.7 WARRANTY

A. Warranty Period: 12 months from date of Substantial Completion. The manufacturer shall repair or replace software and hardware that fails in materials or workmanship within specified warranty period. The SSI shall provide the Owner with an active software subscription agreement that allows the Owner access to software updates during the full 1-year warranty period.

1.8 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. Proximity Readers: Furnish 1 spare proximity reader for each type provided.

PART 2 - PRODUCTS

2.1 NETWORK CONTROLLERS

A. Manufacturers: LenelS2, Avigilon

B. Description: At the top tier is the Network Controller, which shall contain the database engine, web server, application software, and configuration data. It is at this level that System Users, through a browser interface, shall interact with the access control system, set configurations, monitor activities, run reports, and manage alarms.

C. Network Controller:

1. The network controller shall include the following features:

a. Network Nodes Supported: 64
b. Processor: Intel® Atom™ N2800
c. Portals: Configured for 32
d. RAM: 4 GB total
e. Storage Capacity: 20 GB
f. Ethernet Ports: 1 (10/100)
g. Operating Temperature: 32° to 95° F (0° to 35° C)
h. Relative Humidity: 85% at 35°C non-condensing
i. Power Supply: 86 to 264 VAC, 47/440Hz, 1.5A
j. MTBF: 213,447 hrs
k. Weight: 9.7 lbs. (4.4 kg)

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2.2 NETWORK NODES

A. Manufacturers: LenelS2, Avigilon

B. Description: The Network Node, an intelligent device with native TCP/IP support, shall make and manage access control decisions with data provided by the network controller, and it shall manage the communication between the Network Controller and Application blades connected to the system's inputs, outputs, and readers. The Node shall be supplied with 12V DC at a minimum of 3 amps. The Node blade shall supply all Application blades in the node with power. The Network Node shall be available in three configurations: a combined network controller/network node blade; a standalone Network Node blade, and a MicroNode with included Access Control blade. Each Network Node shall support up to seven Application blades except for the MicroNodes. Communications between the node and network controller shall be encrypted and authenticated (SHA-1). SSI shall provide and install the required number of network nodes to support all proximity readers.

C. Network Nodes:

1. Each network node shall include the following capabilities:

a. Application blades: 7
b. Access control readers: 14
c. Access Levels: 512
d. Portals: 14
e. Portal Groups: 64
f. Readers: 14
g. Reader Groups: 128
h. Supervised Inputs: 56
i. Input Groups: 64
j. Relay Outputs: 56
k. Output Groups: 64
l. Temperature Monitor Inputs: 56
m. Elevators: 14
n. Floors: 52
o. Floor Groups: 64
p. Credential storage: 20,000
q. Activity Log records: 27,000

2.3 ACCESS CONTROL BLADES

A. Manufacturers: LenelS2, Avigilon

B. Description: The Application blades shall interface with the network controller through the Network Node. The Application blades shall be blade-style circuit cards. This project shall utilize one type of application blade, the "access control blade". The access control blade shall support 2 readers (input devices such as keypads, RFID devices or Biometric readers), 4 supervised inputs and 4 relay outputs. SSI shall provide and install the required number of access control blades to support all readers.

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C. Access Control Blade:

1. The access control blade shall receive power via the ribbon cable bus directly from the Node Blade. The access blade shall supply up to 400 milliamps of power to one reader or 200 milliamps of power to each of two readers.
2. The access control blade shall include the following features:

a. 7-pin reader connectors: 2
b. Maximum reader wire length: 500 feet (152 m) (18 AWG twisted, shielded)
c. Power available to readers: 400 milliamps
d. 2-pin supervised input connectors: 4
e. Maximum input wire length: 2000 feet (610 m) (22 AWG twisted, shielded)
f. 3-pin relay output connectors: 4
g. Maximum output wire length: Determined by the peripheral device

2.4 ACCESS MANAGEMENT SOFTWARE

A. Manufacturers: LenelS2, Avigilon

B. Description: The access control system shall integrate, within a web browser interface, access control and alarm monitoring applications. These applications shall be embedded in a three-tier software architecture.

C. Operating System and Application Software:

1. The embedded operating system for the solid-state Network Controller shall be the Linux Ubuntu operating system. The operating system kernel shall be open-source and no operating system training or certification shall be necessary.
2. The application software shall be embedded in the system. The database shall be an embedded PostgreSQL relational database requiring a small footprint and provides high reliability. The web server shall be based on an embedded Apache™ web server enabling users to access and operate the system using a standard web browser.

D. Software Licensing:
1. Software licensing shall be based upon the number of readers, cameras, and select features for one Network Controller. Software license upgrades shall be available if system reader and camera capacity must be raised. The user license shall be valid in perpetuity and shall include one year of software updates from the date of shipment from the factory.
2. Licensing shall be controlled by a Product Key and an Activation Key. The Product Key contains the licensed system features and limits. To upgrade your system license to enable more cameras or more doors you will need a new Product Key. The Activation Key contains the warranty expiration date. The keys are locked to the system license number. The system license number shall be viewable on-screen on the Support: About page

E. Software Upgrades: Software upgrades shall be possible from a browser on any network-connected PC, by uploading a software update to the Controller. Controllers shall automatically upgrade all connected nodes. No client software installation shall be necessary.

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F. Personnel Data: The access control system shall maintain person data relating to access control, system user privileges, photo identification, system activity, and contact information.

1. All person data in the system shall be integrated onto one tabbed page for viewing, editing, and deletion by system users.
2. A system user holding at least an 'Administer' user role shall be able to create, delete, and modify person records, including access levels.
3. A system user holding at least a "Setup" user role shall be able to configure the display of person records. For example, the user shall be able to hide various tabs, and configure the User-defined tab by changing the tab label and customizing any of the 20 data fields that appear on the tab. The user shall also be able to define UDF value lists, which can be displayed as pre-entered drop-down lists for user-defined data fields.

G. Data Import and Export: A Data Management Tool shall be provided that supports, via an API, the import and export of personnel data. This tool shall make possible the pre-populating, and ongoing populating, of cardholders into the access control system database.

H. Data Security:

1. Communication between the network controller and the browser shall be secured using SSL. In addition, administrative access to the security management application and the personnel data shall be password protected and controlled by roles-based authorizations.
2. Communication between the network controller and the network nodes shall be encrypted and authentication/tamper detection shall be done using the SHA-1 algorithm.
3. Communication between the network controller and other systems (when using the API) shall be secured using SSL and authentication/tamper detection shall be done using the SHA-1 algorithm.

I. Data Backups: It shall be possible to configure regular automatic database backups.

1. It shall be possible to back up a solid-state Network Controller to a built-in solid state hard drive.
2. It shall also be possible to save backups from any controller to separate network attached storage (NAS) and file transfer protocol (FTP) servers.
3. It shall also be possible to setup regular automatic creation of database archive files.

J. On-board Data Management: Each night the system shall truncate a sufficient number of the oldest records held on-board to reduce the database to its set limit, if required. This shall create the needed storage space for additional system activity records. Truncation will be performed on a First-in, First-out (FIFO) basis.

K. User Roles and Permissions: There shall be 4 pre-programmed levels of User Roles, and a total of 16 possible Custom User Roles that can be configured in the system, with different permissions for each user:

1. Master Partition Monitor: These users may use the functions in the Monitor menu only within the Master (default) partition. Monitor functions shall include viewing the activity log, cameras, and floor plans.
2. Master Partition Administer: These users may use the functions of both the Administration and Monitor menus only within the Master (default) partition. Administrative functions shall include adding and editing person information in the

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enrollment database, issuing and revoking cards, generating reports, and performing database backups.

3. Master Partition Setup: These users may use the functions of the Setup, Administration, and Monitor menus only within the Master (default) partition. Setup functions shall include defining access control, alarm event behavior, camera settings, floor plan images and configurations, holiday and time specifications. Setup functions shall also include: designation of network resources such as time and DNS servers, email and network storage settings; performance of system maintenance such as database backup and restore, software updates and file cleanups; designation of time zone, daily backup schedule and enrollment readers.
4. Full System Setup: These users may use the functions of all menus in all partitions.
5. Custom User Roles: In addition to the roles above the system shall also support the creation of detailed user permissions regarding which cameras, floor plans, elevators, events, access levels, portals, reports, and personal data fields the system user may see, edit, delete, or control.

L. Alarm Events: The system shall be capable of managing alarm events.

1. It shall be possible to delay an input's change to the Alarm state by a specified number of seconds. The range of delay options shall be .5 seconds or 1-120 seconds.
2. It shall be possible to associate specific actions with each alarm event. These actions may include, but are not limited to:
    a. Lock and Unlock portals.
    b. Activate and Deactivate relay outputs.
    c. Arm and Disarm input groups.
    d. Pulse outputs or output groups.
    e. Arm and Disarm alarm panels.
    f. Send emails and SMS messages.
    g. Move cameras to preset positions.
    h. Switch to a video monitor.
    i. Record video.
    j. Momentarily unlock portals.
    k. Display ID photos.
    l. Change the threat level for a location, and (optionally) for its sub-locations.
    m. Make entries in the activity log.
    n. Play a digital sound file; it shall be possible to specify that it play in a loop until cleared or acknowledged.
    o. Display alarms in different colors.
    p. Set a priority for an alarm (one of 20 levels, with 1 being the highest).
    q. Require a duty log entry.
    r. Clear alarm automatically or require an acknowledgement.
3. A system user holding at least a "Setup" user role shall be able to create, delete, and modify alarm system inputs, input groups, outputs, output groups, alarm panels, and events.
4. It shall be possible to trigger events based on system activity such as:

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a. Failed login attempts.
b. Video motion detection.
c. Camera failure and camera restore events.
d. Valid or Invalid card reads.
e. Portals held or forced open.
f. Valid card reads with a specified access level.
g. Inputs entering an alarm state.
h. High and low temperature events.
i. Alarm panel arming failures.
j. Alarm panel zone faults.
k. Tailgating and pass-back violations.
l. Occupancy limit violations.
m. Zone empty violations.
n. Node power failure, communication failure, timeout, and tamper events.

5. It shall be possible to clone an event which creates an event with all attributes of the original, needing to change only the event's name and any attributes it will not have in common.

M. Network-based Camera and Video Surveillance: The system shall provide live IP video surveillance capability. The number of supported cameras shall be limited only by license. The system's video capabilities shall include video monitor switching based on access activity. The system shall provide monitoring, configuration, and administration of IP video. Cameras can be separately monitored or monitored in groups.

1. Presets: The system shall support the creation, deletion, and editing of camera preset positions in the system. It shall also be possible to save changes in preset positions directly to a camera website.
2. Views: The system shall support the creation, deletion, and editing of multiple camera views, specifically Quad views (four cameras). The application shall provide a drop-down pick list for selecting current views or naming of new views.

N. Activity Monitoring:

1. The system shall support a Monitoring Desktop that integrates video, system activity logs, floorplans, ID photos, and alarm notifications.
2. Activity Log viewing includes one-click navigation to person records.
3. The system shall support a Widget Desktop that allows the creation of custom monitoring layouts. Within a custom layout, widgets display live video, system activity logs, alarm notifications, ID photos, floorplans, duty log entries, portal status displays, and DMP intrusion panels.
4. Many widgets support multiple partition viewing and filtering. For example, the Activity Log widget can display data from multiple partitions and data filtered by event type or reader group, and/or based on the text content of the event.
5. It shall also be possible to view cameras, activity logs, and floorplans on separate monitoring pages within the application.

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6. The system shall support tracing a person's activity in the current partition if the "Trace this person" check box is selected on the person record. The traced activity is displayed in bold in the color selected for "Trace person log color" on the Network Controller page. In addition, if an event is selected for "Trace person event" on the Network Controller page, it is triggered each time a traced person makes an access attempt. These event activations can be reported using a Trace people filter in a custom history report.

O. Access Control:

1. The access control system shall be able to make access control decisions, define a variety of access levels and time specifications, write system activity into a log file, maintain a personnel enrollment database, receive signals from input devices such as door switch monitors, card readers and motion detectors, energize devices such as door locks and alarms via outputs.

P. Threat Levels:

1. It shall be possible to configure up to eight threat levels. It shall be possible to alter security system behavior through the use of threat levels. Groups of threat levels may be created and assigned to portal groups, access levels, input groups, output groups, floor groups, and event actions. The behavior of groups, access levels, and event actions with assigned threat level groups shall change based upon the current system threat level.
2. The system shall support 32 threat level groups.
3. It shall also be possible to change the system threat level in response to an alarm event.
4. The current system threat level shall display in the title bar of the security application interface and on floorplans.

Q. Location-based threat levels: The system administrator shall have the ability to define locations. This allows for threat levels to be assigned to individual locations.

1. Within each parent location, sub-locations can be created, and additional sub-locations can be created within each of these, and so on. This creates a location hierarchy.
2. Portals can be assigned, and threat levels applied, to any location within the hierarchy.

R. Appropriate Use banner: The system administrator shall have the ability to enter text (such as an appropriate use statement) to be displayed on the login page.

S. Reports:

1. The access control system shall be capable of producing a variety of predefined reports regarding software and security hardware configuration, event history, and the administration of people within the system. In addition, an easy to use query language shall be included to create ad hoc reports. The query language shall be documented in the online help system. Alternatively, it shall be possible to specify a query by use of point-and-click.

2.5 iCLASS SE READERS

A. Manufacturer: HID

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B. Description: SSI shall provide and install HID iClass SE R40 readers as specified herein. The basis for the specification is HID.

C. Readers:
1. HID 920NTNNEK00000 for proximity only. HID 921NTNNEK00000 for proximity/keypad.
2. The readers shall include the following features:

a. Dimensions: 84mm x 122 mm x 24 mm (3.3” x 4.8” x 1.0”) for model 920N and 88mm x 122 mm x 28 mm (3.3” x 4.8” x 1.1”) for model 921N
b. Material: Polycarbonate UL 94
c. Power Supply: 5-16VDC
d. Current requirements (standard power mode): 65mA for model 920N and 85mA for model 921N
e. Operating temperature: -35° C to +66° C (-31° F to 150° F)
f. Transmission frequency: 13.56 MHz
g. Color: black
h. Environmental: Outdoor and Indoor rated, IP55/IP65 (with optional gasket)
i. Use: Indoor/outdoor
j. Communications & Panel Connection: Wiegand, Clock & Data, and OSDP via RS-485 using Pigtail (18 in / 0.5 m) or Terminal Strip
k. Device Management: HID Reader Manager / OSDP configuration

2.6 iCLASS SE Key Fobs

A. Manufacturer: HID

B. Description: SSI shall provide two hundred (200) iCLASS SE Key Fobs to the Owner upon substantial completion. The Owner shall be responsible for enrolling the key fobs into the Access Control System. The basis for the specification is HID.

C. Key Fobs:

1. HID model 3250PNNMN.
2. The iCLASS SE key fobs shall include the following features:

a. Dimensions: 3.95 cm x 3.18 cm x 0.60 cm (1.555” x 1.25” x 0.235”)
b. Operating frequency: 13.56 MHz
c. Typical Maximum Read Range: Up to 70mm (depending on the reader in use)
d. Weight: 0.14 oz
e. Construction: Ultrasonically welded ABS Shell with TPE Insert
f. Operating Temperature: -45° C to + 70° C (-50 ° F to 160 ° F)
g. Memory Type: EEPROM, read/write
h. Write Endurance: Min 100,000 erase/write cycles
i. Data Retention: Min 10 years non-volatile data retention
j. Slot Punch: Key Ring Hole

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2.7 REQUEST-TO-EXIT MOTION DETECTOR

A. Manufacturers:

1. Kantech
2. Securitron
3. Bosch

B. Description: SSI shall provide request-to-exit motion detectors as shown on the plans. The PLC system shall provide the required number of inputs to integrate with all request-to-exit detectors. The basis for the specification is Kantech.

C. Request-to-Exit Motion Detector:

1. Kantech model T.REX-LT.
2. The request-to-exit detectors shall include the following features:

a. Detector Type: Passive Infrared
b. Filter Technology: Digital Signal Processing (DSP)
c. Detector Lens: Curtain-type Fresnel lens
d. Detection Range: Narrow Targeting Area; 3m. Whole Body; 6m.
e. Main Relay Contacts: SPDT, 1A max @ 30VDC max
f. Tamper Switch: N.C., 100mA max @ 30VDC max
g. Indicator Light: Red/Green LED
h. Physical Dimensions: 4.5 x 19 x 4.75cm (H x W x D)
i. Power Consumption: 12-28 VDC, 50mA
j. Accessories: Provide T.REX-PLATE for mounting to single-gang box

2.8 OPTICAL WIEGAND DATA EXTENDER

A. Manufacturer: COMNET

B. Description: SSI shall provide and install Optical Wiegand Data Extenders for control and monitoring of the site-located proximity readers and gate control. The remote extenders shall be located in Nema 4X enclosures as specified in section 280510 and the central units shall be located at the security electronics head-end equipment racks. The basis for the specification is Comnet.

C. Optical Wiegand Data Extender:
1. Comnet model FDW1000M/C and FDW1000M/R.
2. The extender shall include the following features:

a. Interface: Wiegand, Strobed (Clock and Data), and F-2F
b. Relays: Maximum switching voltage and current; 220VDC 30W, 1A, resistive load only, 250VAC, 37.5VA, 1A
c. Fibers: Multimode; Loss Budget 13dB, 850nm, 2 fibers
d. Connectors: Optical – ST; Data/Power/Relay – removable screw terminal blocks
e. Power: Input; 8 to 16VDC @ 200 mA Max
f. Operating Temperature: -40° C to +75° C
g. Storage Temperature: -40° C to + 85° C

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h. Relative Humidity: 0% to 95% (non-condensing)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect both the substrate and conditions under which Work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. Examine scheduled openings, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance of the installed access control system.

C. Examine roughing-in for electrical source power to verify actual locations of wiring connections before electrified and integrated access control door hardware installation.

D. Examine roughing-in for LAN and control cable conduit systems to controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

E. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances.

F. Comply with manufacturer's installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

G. Precautions shall be taken to guard against electrostatic and electromagnetic susceptibility and interference.

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

3.2 PREPARATION

A. Doors and frames at scheduled access controlled openings to be properly prepared to receive specified electrified and access control hardware and connections without additional in-field modifications.

3.3 INSTALLATION

A. Provide complete access control system as specified herein.

B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

C. All system head-end equipment to be contained within equipment cabinets or enclosures.

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D. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

E. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

F. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

G. Wires shall not be nicked, have strands removed, or have frayed strands when removing insulation or terminating.

3.4 CONNECTIONS

A. Ground equipment according to manufacturer’s recommendations.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust the access control system 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 pass/fail reports:

1. Proximity reader inspection: SSI shall perform an inspection of each proximity reader to ensure that each device works correctly.

2. Request to exit detector inspection: SSI shall perform an inspection of each request-to-exit motion detector to ensure that each device works correctly.

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

3.6 CLEANING AND PROTECTION

A. Protect all hardware stored on construction site in a covered and dry place. Protect exposed hardware installed on doors during the construction phase. Install any and all integrated access control door hardware at the latest possible time frame.

B. Clean adjacent surfaces soiled by access control system installation.

C. Clean operating items as necessary to restore proper finish and provide final protection and maintain conditions that ensure access control door hardware is without damage or deterioration at time of owner occupancy.

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3.7 DEMONSTRATION

A. A trained service representative will perform system maintenance training at the owner's facility once the final inspection is complete. Refer to Division 01 Section "Demonstration and Training."

B. Training shall be video recorded.

END OF SECTION 28 13 00

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SECTION 28 23 00

IP VIDEO COMMUNICATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01 and Division 28 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the requirements for an IP video communication system. The IP video communication system shall be integrated with the overall Electronic Security System.

B. The video management system shall be integrated with the PLC system and GUI software to allow automatic (connecting intercom stations or alarm activities) or manual call-up of any camera connected to the system. Reference section 284620 for software functionality.

C. The SSI shall provide all new cameras as indicated on the plans and specifications. All existing analog cameras shall be removed and disposed of. New network cabling shall be installed for existing analog camera locations being replaced with new network cameras. All cameras shall terminate to new SSI-provided PoE switches.

D. The SSI shall provide new a video management system (VMS) to replace the existing VMS. Existing VMS equipment shall be removed and turned over to the Owner. The new VMS shall support all cameras, encoders and video client workstations included in the project.

E. System shall include a complete IEEE 802.3 100/1000 BASE-T Local Area Network that interfaces the GUI control stations to the IP camera servers. This security network shall be a closed network. The IP camera servers shall include multiple NICs. One NIC in each IP camera server shall be connected to the Owner's LAN.

F. The SSI shall provide the following quantities of video client workstations and monitors:

1. One (1) video client workstation, with one (1) 24" monitor located in Jail Commander C124.
2. One (1) video client workstation, with one (1) 43" monitor located in Dispatch & Turnkey/Control Room 089/C126.
3. One (1) video client workstation with two (2) 24" monitors located in Dispatch & Turnkey/Control Room 089/C126.
4. One (1) video client workstation, with two (2) 27" monitors located in Control Room D200.
5. One (1) video client workstation, with two (2) 50" monitors located in Control Room D200.

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G. PCs (provided by the Owner) shall be capable of accessing the IP video communication system using the video management system software. Software shall be configured to only allow those users with valid credentials (i.e. logins and passwords) to access the IP video communication system. The SSI shall train the Owner on the installation and configuration of the video management system software. Installation of the software on Owner-provided PCs shall be the responsibility of the Owner. The Owner shall provide PCs that meet the recommended software and hardware requirements of the video management system.

H. The video management system shall include the ability to mask areas of the video images. SSI shall mask toilet and shower areas of video images from cameras located in the detention areas of the facility. SSI shall coordinate with the Owner's requirements during final configuration of the system.

I. The SSI shall provide initial configuration of the camera views for the video client software for each GUI control station location, with input from the Owner.

J. All cameras in the video management system shall be licensed as required for proper viewing and recording. SSI shall provide licenses for all cameras and encoders in the system.

K. The video management system shall include the required quantity of IP camera servers and storage devices required to accommodate all cameras as shown on the plans, with cameras configured at their maximum allowable resolution and adhering to the following recording parameters:

1. 10 IPS per camera (or if not possible with specified camera, the maximum allowable rate for that camera).
2. Inmate Property "transaction" camera shall be configured to record at 22 IPS.
3. Record based on motion. SSI shall assume a 50% overall motion activity level.
4. All cameras shall be configured for minimum stored image retention of 365 days.
5. SSI shall provide a minimum of 864TB of usable storage after RAID6. SSI shall configure servers and storage units with enough drives in RAID 6 configuration to support the required storage. Architect shall verify installed storage prior to issuing substantial completion certificate.

L. For stand-alone microphone locations, provide Louroe model Verifact A and D-V line level microphones. Microphones shall terminate to Axis cameras and Axis Audio & I/O interface units as indicated on the security plans.

M. The IP video communication system shall include the following main components:

1. Cameras
2. Video Management System
3. Audio & I/O Interface
4. Encoders
5. Microphones
6. Media Converter Cabinet
7. Surveillance Cabinet
8. CAT6 Patch Panels
9. Network switches
10. Video Client Workstations

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1.3 DEFINITIONS

A. VMS: Video Management System

B. PoE: Power-Over-Ethernet

C. NIC: Network Interface Card

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: Detail equipment enclosure assemblies and indicate dimensions, loads, required clearances, components, and location of each field connections.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For IP video communication system to include in operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Schedules detailing model numbers, locations, titles, and termination locations of all cameras, switches and video management system equipment in the system.

1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

1.6 COORDINATION

A. The SSI shall coordinate the exact location of cameras with the Architect and Owner to obtain the best possible view.

1.7 WARRANTY

A. Warranty Period: 12 months from date of Substantial Completion. The manufacturer shall repair or replace software and hardware that fails in materials or workmanship within specified warranty period.

B. Special warranty: The IP camera servers shall include a 3-year hardware warranty from the manufacturer from the date of purchase. During this 3-year period, all software updates shall be free of charge.

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1.8 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. Cameras: Furnish 1 spare “Type 4” and “Type 10” camera.

PART 2 - PRODUCTS

2.1 CAMERAS

A. Manufacturers:

1. Axis
2. Hanwha

B. Description: This specification is based on cameras manufactured by Axis and Hanwha. Multiple camera types have been defined below. Each camera TYPE includes a description of what hardware shall be included. SSI shall reference the camera schedule included in this specification section for a complete list of cameras and TYPES for the project.

C. Camera TYPE 1 (360° Multi-directional with IR, 15MP, remote focus and zoom, WDR, IP66, IP67, IK09, Nema 4X)

1. Axis model P3719-PLE

D. Camera TYPE 2 (180° Panoramic, 8MP, WDR, IP66, IK10, Nema 4X)

1. Hanwha model PNM-9022V

E. Camera TYPE 3 (360° Indoor/Outdoor Dome with IR, 12MP, WDR, IP66, IK10, Nema 4X)

1. Axis model M3058-PLVE

F. Camera TYPE 4 (Outdoor dome with IR, 2MP, remote focus and zoom, WDR, IP66, IK10)

1. Hanwha model QNV-6082R

G. Camera TYPE 5 (180° Panoramic, 15MP, WDR, IP66, IK10)

1. Hanwha model PNM-9030V

H. Camera TYPE 7 (Fixed dome, 1080p, remote focus and zoom, WDR, built-in microphone, IK10)

1. Axis model P3375-V

I. Camera TYPE 8 (360° Indoor/Outdoor Dome with IR, 6MP, WDR, IP66, IK10, Nema 4X)

1. Axis model M3057-PLVE

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J. Camera TYPE 9 (Corner-mount, 4MP, IR, IP66/69, IK10+, built-in microphone)

1. Axis model Q9216-SLV

K. Camera TYPE 10 (Fixed mini dome, 1080p, WDR, IP66, IK10, Nema 4X)

1. Hanwha model XNV-6011

L. Camera TYPE 11 (Analog HD IR Dome Camera, 1080p, Vari-focal lens, WDR, IP66, IK10)

1. Hanwha model SCV-6083R

M. Camera TYPE 13 (Outdoor dome with IR, 5MP, remote focus and zoom, WDR, IP66, IK10)

1. Hanwha model QNV-8080R

N. Camera TYPE 14 (360° Multi-directional with IR, 8MP, remote focus and zoom, WDR, IP66, IP67, IK09, Nema 4X)

1. Axis model P3717-PLE

O. Camera TYPE 15 (Corner-mount, 3MP, fixed lens, WDR, IP66, IK10+)

1. Hanwha model TNV-7010RC

CAMERA SCHEDULE

CAMERA #	CAMERA TYPE	MODEL	ACCESSORY	MOUNT	TERMINATION LOCATION	NOTES
1	TYPE 4	QNV-6082R		CEILING	SQE#10	
2	TYPE 4	QNV-6082R		WALL	SQE#10	
3	TYPE 4	QNV-6082R		WALL	SQE#10	
4	-	EXISTING		CEILING	SQE#12	
5	-	EXISTING		WALL	SQE#12	
6	TYPE 4	QNV-6082R		CEILING	SQE#10	
7	TYPE 4	QNV-6082R		WALL	SQE#10	
8	TYPE 4	QNV-6082R		WALL	SQE#10	
9	TYPE 4	QNV-6082R		WALL	SQE#12	
10	TYPE 4	QNV-6082R		CEILING	SQE#12	
11	TYPE 4	QNV-6082R		CEILING	SQE#12	
12	TYPE 4	QNV-6082R		CEILING	SQE#12	
13	TYPE 4	QNV-6082R		WALL	SQE#12	
14	TYPE 10	XNV-6011		CEILING	SQE#12	
15	TYPE 4	QNV-6082R		CEILING	SQE#12	
16	TYPE 4	QNV-6082R		WALL	SQE#12	
17	TYPE 4	QNV-6082R		WALL	SQE#12	
18	TYPE 4	QNV-6082R		WALL	SQE#12	
19	TYPE 4	QNV-6082R		WALL	SQE#12	

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20	TYPE 4	QNV-6082R		WALL	SQE#12	
21	TYPE 4	QNV-6082R		CEILING	SQE#12	
22	TYPE 4	QNV-6082R		CEILING	SQE#12	
23	TYPE 4	QNV-6082R		WALL	SQE#12	
24	TYPE 4	QNV-6082R		WALL	SQE#12	
25	TYPE 4	QNV-6082R		CEILING	SQE#12	
26	TYPE 15	TNV-7010RC		CORNER	SQE#12	
27	TYPE 4	QNV-6082R		WALL	SQE#12	
28	TYPE 4	QNV-6082R		CEILING	SQE#12	
29	TYPE 4	QNV-6082R		WALL	SQE#12	
30	TYPE 4	QNV-6082R		CEILING	SQE#12	
31	TYPE 7	P3375-V		WALL	SQE#10	
32	TYPE 7	P3375-V		WALL	SQE#10	
33	TYPE 7	P3375-V		WALL	SQE#10	
34	TYPE 7	P3375-V		WALL	SQE#10	
35	TYPE 3	M3058-PLVE	T94K01D/T91B50	CEILING	SQE#10	1
36	TYPE 7	P3375-V		CEILING	SQE#10	
37	TYPE 14	P3717-PLE		CEILING	SQE#10	1
38	TYPE 3	M3058-PLVE		CEILING	SQE#10	1
39	TYPE 7	P3375-V		CEILING	SQE#10	
40	TYPE 7	P3375-V		CEILING	SQE#10	
41	TYPE 9	Q9216-SLV		CORNER	SQE#10	
42	TYPE 14	P3717-PVE		CEILING	SQE#10	1
43	TYPE 9	Q9216-SLV		CORNER	SQE#10	
44	TYPE 9	Q9216-SLV		CORNER	SQE#10	
45	TYPE 9	Q9216-SLV		CORNER	SQE#10	
46	TYPE 9	Q9216-SLV		CORNER	SQE#10	
47	TYPE 9	Q9216-SLV		CORNER	SQE#10	
48	TYPE 9	Q9216-SLV		CORNER	SQE#10	
49	TYPE 9	Q9216-SLV		CORNER	SQE#10	
50	TYPE 4	QNV-6082R		CEILING	SQE#10	
51	TYPE 10	XNV-6011		CEILING	SQE#10	
52	TYPE 3	M3058-PLVE		CEILING	SQE#10	
53	TYPE 3	M3058-PLVE		CEILING	SQE#10	
54	TYPE 10	XNV-6011		CEILING	SQE#10	
55	TYPE 10	XNV-6011		CEILING	SQE#10	
56	TYPE 10	XNV-6011		CEILING	SQE#10	
57	TYPE 4	QNV-6082R		CEILING	SQE#10	
58	TYPE 4	QNV-6082R		CEILING	SQE#10	
59	TYPE 4	QNV-6082R		CEILING	SQE#10	
60	TYPE 4	QNV-6082R		CEILING	SQE#10	
61	TYPE 8	M3057-PLVE		CEILING	SQE#10	
62	TYPE 4	QNV-6082R		CEILING	SQE#10	

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63	TYPE 4	QNV-6082R		CEILING	SQE#10	
64	TYPE 4	QNV-6082R		CEILING	SQE#10	
65	-	-				
66	-	-				
67	TYPE 7	P3375-V		CEILING	SQE#10	2
68	TYPE 7	P3375-V		CEILING	SQE#10	2
69	TYPE 10	XNV-6011		CEILING	SQE#10	
70	TYPE 3	M3058-PLVE		CEILING	SQE#10	
71	TYPE 14	P3717-PVE		CEILING	SQE#10	
72	TYPE 7	P3375-V		CEILING	SQE#10	2
73	TYPE 7	P3375-V		CEILING	SQE#10	
74	TYPE 4	QNV-6082R		CEILING	SQE#10	
75	TYPE 10	XNV-6011		CEILING	SQE#10	
76	TYPE 10	XNV-6011		CEILING	SQE#10	
77	TYPE 10	XNV-6011		CEILING	SQE#10	
78	TYPE 4	QNV-6082R		WALL	SQE#12	
79	TYPE 4	QNV-6082R		WALL	SQE#12	
80	TYPE 4	QNV-6082R		WALL	SQE#12	
81	TYPE 2	PNM-9022V		WALL	SQE#12	
82	TYPE 2	PNM-9022V		WALL	SQE#12	
83	TYPE 2	PNM-9022V		WALL	SQE#12	
84	TYPE 4	QNV-6082R		CEILING	SQE#12	
85	TYPE 10	XNV-6011		CEILING	SQE#12	
86	TYPE 4	QNV-6082R		CEILING	SQE#12	
87	TYPE 10	XNV-6011		CEILING	SQE#12	
88	TYPE 9	Q9216-SLV		CORNER	SQE#12	
89	TYPE 9	Q9216-SLV		CORNER	SQE#12	
90	TYPE 4	QNV-6082R		CEILING	SQE#12	
91	TYPE 9	Q9216-SLV		CORNER	SQE#12	
92	TYPE 4	QNV-6082R		CEILING	SQE#12	
93	TYPE 9	Q9216-SLV		CORNER	SQE#12	
94	TYPE 11	SCV-6083R		CEILING	SQE#12	3
95	TYPE 10	XNV-6011		CEILING	SQE#11	
96	TYPE 10	XNV-6011		CEILING	SQE#11	
97	TYPE 4	QNV-6082R		CEILING	SQE#11	
98	TYPE 10	XNV-6011		CEILING	SQE#11	
99	TYPE 10	XNV-6011		WALL	SQE#11	
100	TYPE 10	XNV-6011		CEILING	SQE#11	
101	TYPE 10	XNV-6011		CEILING	SQE#11	
102	TYPE 10	XNV-6011		CEILING	SQE#11	
103	TYPE 4	QNV-6082R		WALL	SQE#11	
104	TYPE 4	QNV-6082R		WALL	SQE#11	
105	TYPE 4	QNV-6082R		WALL	SQE#11	

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106	TYPE 4	QNV-6082R		WALL	SQE#11	
107	TYPE 4	QNV-6082R		WALL	SQE#11	
108	TYPE 10	XNV-6011		CEILING	SQE#11	
109	TYPE 10	XNV-6011		CEILING	SQE#11	
110	TYPE 10	XNV-6011	SBV-116B	WALL	SQE#11	
111	TYPE 10	XNV-6011	SBV-116B	WALL	SQE#11	
112	TYPE 10	XNV-6011	SBV-116B	WALL	SQE#11	
113	TYPE 10	XNV-6011	SBV-116B	WALL	SQE#11	
114	TYPE 10	XNV-6011	SBV-116B	WALL	SQE#11	
115	TYPE 10	XNV-6011	SBV-116B	WALL	SQE#11	
116	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#10	
117	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#10	
118	TYPE 2	PNM-9022V		WALL	SQE#10	
119	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#12	
120	TYPE 2	PNM-9022V		WALL	SQE#11	
121	TYPE 2	PNM-9022V		WALL	SQE#12	
122	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#12	
123	TYPE 13	QNV-8080R		WALL	SQE#12	
124	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#10	
125	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#10	
126	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#11	
127	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#11	
128	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#11	
129	TYPE 10	XNV-6011		CEILING	SQE#11	
130	TYPE 10	XNV-6011		CEILING	SQE#11	
131	TYPE 10	XNV-6011		WALL	SQE#11	
132	TYPE 13	QNV-8080R		WALL	SQE#11	
133	TYPE 13	QNV-8080R		WALL	SQE#11	
134	TYPE 4	QNV-6082R		WALL	SQE#11	
135	TYPE 2	PNM-9022V		WALL	SQE#11	
136	TYPE 4	QNV-6082R		WALL	SQE#11	
137	TYPE 2	PNM-9022V		WALL	SQE#11	
138	TYPE 2	PNM-9022V		WALL	SQE#11	
139	TYPE 4	QNV-6082R		WALL	SQE#11	
140	TYPE 4	QNV-6082R		WALL	SQE#11	
141	TYPE 2	PNM-9022V		WALL	SQE#11	
142	TYPE 2	PNM-9022V		WALL	SQE#11	
143	TYPE 4	QNV-6082R		WALL	SQE#11	
144	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#10	
145	TYPE 1	P3719-PLE	T94N01D/T91D61/T91A64	CORNER	SQE#10	

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146	TYPE 5	PNM-9030-V	SBP-276HM/SBP-300WM1/T95A67/T98A18-VE Media Converter Cabinet A/T8133/CABINET LOCK A/T8612 SFP MODULE	POLE	SQE#11	4
147	TYPE 5	PNM-9030-V	SBP-276HM/SBP-300WM1/T95A67/T8133/T98A18-VE Surveillance Cabinet/CABINET LOCK A/Electrical Safety Kit	POLE	SQE#11	4
148	TYPE 4	QNV-6082R		PEDESTAL	SQE#11	5
149	-	-		-	-	-
150	TYPE 13	QNV-8080R	SBV-136BW	FENCE	SQE#11	5
151	TYPE 13	QNV-8080R	SBV-136BW	FENCE	SQE#11	5
152	TYPE 4	QNV-6082R		CEILING	SQE#10	

Notes:

1. Provide local network connection to Axis T6101. Axis T6101 shall terminate to PoE switch. Provide Louroe VERIFACT A line level microphone to connect to T6101.
2. Provide Louroe VERIFACT D line level microphone and connect directly to camera. Microphone shall be wall-mounted at 48" AFF.
3. Provide video balun at camera and head-end location. Provide Axis M7011 single-channel encoder at head-end for camera. Wire local ON/OFF switch to camera power.
4. Camera and cabinet shall be mounted on light pole. Reference Electrical and Security Site drawings for location.
5. Reference Electrical and Security Site drawings for location.

2.2 VIDEO MANAGEMENT SYSTEM

A. Video Management System Software Manufacturer:

1. ExacqVision Professional series (to match Owner’s existing VMS)

B. IP Camera Server System Manufacturer:

1. ExacqVision Z-series
2. BCDVideo Professional 2U 18-Bay series

C. Description: SSI shall provide the required quantity of IP camera servers, licenses and storage to support all cameras as shown on the plans and specifications. SSI shall provide a minimum of four camera servers.

D. IP Camera Servers:

1. Processor: Intel® E3 Xeon®
2. Server Operating System: Windows 10
3. Memory: 32GB
4. Video Outputs: (1) VGA, (1) HDMI, (1) DVI-D
5. NIC: 4 x 1 Gbe
6. USB(s): 6 (2 front, 4 rear)
7. RAID: Data Configured RAID 6
8. Configured Storage: 240TB, RAID6

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9. Input Voltage: 120/240 VAC auto-sensing
10. Power Supplies: Dual Hot Swap
11. Operating Temperature: (Min) 40°F – (Max) 95°F [(Min) 4.5°C – (Max) 35°C]
12. Dimensions (HxWxD): 7.0” x 16.875” x 27”
13. Weight (max): 90 lbs.
14. Approved Manufacturers: Exacq Technologies 4U “Z-Series” with optional P/Ns 5000-40393, 5000-40141, 5000-20070, BCDVideo
15. Provide Raritan model RKP117 (or approved equal) 1U 17" LCD Keyboard Drawer w/touchpad, 18.12" deep.
16. Provide Tripp-Lite model B042-016 16-Port KVM USB VGA Switch with required quantity of USB/PS2 Combo Cable Kits, 10', model P780-010 to administer the system.

2.3 AUDIO & I/O INTERFACE

A. Manufacturer:

1. Axis

B. Description: SSI shall provide the required number of Audio & I/O interface units to support microphones to be incorporated into the overall video surveillance system. The basis for the specification is Axis.

C. Audio & I/O Interface:

1. The audio & I/O interface unit shall include the following features:

a. Audio Steaming: Two-Way
b. Audio Compression: Based on the audio compression capabilities of the connected camera
c. Audio input/output: External microphone input or line input, line output
d. I/O Interface: Two configurable supervised inputs/digital outputs, 12VDC output, max load 50mA
e. Security: Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, Digest authentication, User access log, centralized certificate management
f. Casing: Polycarbonate casing, metal base, encapsulated electronics
g. Display and indicators: Status LED
h. Power: Power over Ethernet (PoE) IEEE 802.3af/802.3at Type 1 Class 2 or 3 (selectable), Axis T6101 feeds power to the camera
i. Connectors: PoE in: RJ45 10BASE-T/100BASE-TX, PoE out: RJ45 10BASE-T/100BASE-TX, I/O: 4-pin 2.5 mm terminal block, Audio: 3.5mm mic/line in, 3.5mm line out
j. Mounting: Connected anywhere between switch and camera. Maximum total distance using a CAT5 cable: 100m (330 ft).
k. Operating conditions: -40°C to 55°C (-40°F to 149°F), Humidity 10-85% non-condensing)
l. Dimensions: 3.5” x 2.5” x 1”
m. Weight: 0.22 lb
n. Approved manufacturer: Axis model T6101.

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2.4 ENCODERS

A. Manufacturer:

1. Axis

B. Description: SSI shall provide the required number of encoders to support all analog cameras to be incorporated into the overall video surveillance system. The basis for the specification is Axis.

C. Encoder:

1. The encoder shall include the following features:

a. Video Compression: H.264, Motion JPEG
b. Resolutions: 176x120 to 720x480
c. Frame rate: 30fps in all resolutions
d. Video streaming: Multiple, individually configurable streams in H.264 and Motion JPEG, Axis Zipstream technology in H.264, controllable frame rate and bandwidth
e. Image settings: Compression, color, brightness. Rotation; 90°, 180°, 270°. Aspect ratio correction, mirroring of images, text and image overlay, privacy mask, enhanced de-interlace filter, video termination, anti-aliasing, temporal noise filtering, sharpness, noise reduction, local enhancement
f. Security: Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, Digest authentication, User access log, centralized certificate management
g. Analytics: Video motion detection, Active tampering alarm
h. Event triggers: Analytics, Edge Storage Events, Video loss
i. Casing: PC+ABS CX7240
j. Memory: 256MB RAM, 256MB Flash
k. Power: Power over Ethernet (PoE) IEEE 802.3af/802.3at Type 1 Class 1
l. Connectors: Analog composite video BNC input, 10BaseT/100BaseTX PoE, RS485/RS422
m. Storage: Support for microSD/microSDHC/microSDXC card
n. Operating conditions: 0°C to 50°C (32°F to 122°F), Humidity 10-85% non-condensing)
o. Approved manufacturer: Axis model P7011.

2.5 MICROPHONES

A. Manufacturer:

1. Louroe

B. Description: SSI shall provide microphones as shown on the plans. The microphones shall be omni-directional, low impedance, electret condenser microphones with built-in preamps for producing line level audio. The basis for the specification is Louroe.

C. Microphones:

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1. The microphones shall include the following features:

    a. Sensitivity: -45 dBV/Pa
    b. Frequency response: 50 Hz to 15 kHz
    c. Output: Line Level (0 dBV, 600Ω @1kHz)
    d. Current drain: 10 mA
    e. Supply Voltage: 12 VDC
    f. Microphone housing: High-impact anti-static ABS (VERIFACT-A)
    g. Dimensions: 4” dia x 1 ½”H
    h. Approved manufacturer: Louroe model VERIFACT-A for ceiling applications and VERIFACT D-V for wall-mount locations.

2.6 MEDIA CONVERTER CABINET

A. Manufacturer:

1. Axis

B. Description: SSI shall provide media converter cabinets to support cameras covering parking lot areas and located on camera poles. The basis for the specification is Axis.

C. Media Converter Cabinet:

1. The media converter cabinet shall include the following features:

    a. Casing: Polycarbonate cabinet and stainless-steel mounting plate
    b. Environment: Indoor/Outdoor
    c. Power: Input (120VAC), 90-175 VAC, Max. 4A; Input (230VAC): 90-264 VAC, Max. 4A
    d. Connectors: 2 x RJ45 connectors (10/100 Mbps), 2 x SFP connectors (100/1000Mbps) for SFP fiber optic modules or SFP to copper modules
    e. Operating Conditions: -40°C to 65°C (-40°F to 149°F), humidity 10-100% RH (condensing)
    f. Weight: 4.4kg (9.7 lb)
    g. Included accessories: Unit shall include power supply, electrical safety kit, media converter, DIN Clip for midspan, Cabinet Lock A
    h. Approved manufacturer: Axis model T98A18-VE Media Converter Cabinet A
    i. Provide Axis pole-mount adapter model T95A67 and Axis 30W midspan model T8133 per cabinet location. Provide SFP module compatible with media converter and installed fiber optic cable.

2.7 SURVEILLANCE CABINET

A. Manufacturer:

1. Axis

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B. Description: SSI shall provide surveillance cabinets to support cameras covering parking lot areas and located on camera poles. The basis for the specification is Axis.

C. Surveillance Cabinet:

1. The surveillance cabinet shall include the following features:

a. Casing: Polycarbonate cabinet and stainless-steel mounting plate
b. Environment: Indoor/Outdoor
c. Power: Input (120VAC), 90-175 VAC, Max. 4A; Input (230VAC): 90-264 VAC, Max. 4A
d. Operating Conditions: -40°C to 65°C (-40°F to 149°F), humidity 10-100% RH (condensing)
e. Weight: 3.5kg (7.7 lb)
f. Included accessories: Unit shall include electrical safety kit, DIN Clip for midspan, Cabinet Lock A
g. Approved manufacturer: Axis model T98A18-VE Surveillance Cabinet
h. Provide Axis pole-mount adapter model T95A67 and Axis 30W midspan model T8133 per cabinet location.

2.8 CAT6 PATCH PANELS

A. Manufacturers:

1. Leviton
2. ICC
3. Commscope

B. Description: SSI shall provide 24-port and 48-port CAT6 patch panels to support all network field cabling terminations at rack-mount security equipment enclosure locations. Cabling for cameras, PCs, and other network devices shall terminate to these CAT6 patch panels. The SSI shall provide CAT6 patch cables between patch panels and network switch equipment. The basis for the specification is ICC.

C. CAT6 Patch Panels:

1. The CAT6 patch panels shall include the following features:

a. 24-port and 48-port Patch Panel: 16GA CRS
b. Jack Housing: High-impact, Flame Retardant Plastic, UL 94V-0
c. Spring Wire: Phosphor Bronze
d. 110 Connector: Phosphor Bronze Alloy with 100 micro-inch Alloy
e. Gold Rating: 50 Micro-inches of Gold over 100 micro inches of Nickel
f. Surface Finish: Black Powder Coat
g. Mating Force: 100 Grams MIN/Contact
h. Temperature Range: -40°C to 70°C
i. Plug Retention in Jack: 50N (11 LBS SQ)
j. IDC Wire Gauge: 22-24 AWG

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k. Current Rating: 1.5A DC
l. Contact Resistance: 2.5 MILOHMS MAX

2.9 NETWORK SWITCHES

A. Manufacturers:

1. Cisco
2. HP
3. Alcatel-Lucent
4. Comnet

B. Description: The SSI shall provide the quantity of 24-port to 48-port Layer 2/3 PoE switches to support all video network devices. Stacking cables shall be installed to connect similar switches at the same location(s). SSI shall provide and install the required quantity of 1GbE and 10GbE SFP optical transceivers at switch locations as required. The SSI shall provide self-managed switches for site-located gate control equipment.

C. 24-port Layer 2/3 PoE Switches:

1. The Layer 2/3 PoE switches shall include the following features:

a. Gigabit RJ-45 port count: 24 PoE+
b. 1G SFP+ port count: 2
c. 1G/10G SFP+: 4
d. MACSec capable ports: All 1G RJ45
e. USB port: 1
f. Console port: 1
g. Primary slide-in PSU slot: 1
h. Backup slide-in PSU slot: 1
i. Fans: 2
j. File system flash: 1GB
k. RAM: 1GB
l. Max switching ASIC capacity: 168 Gb/s
m. Switch capacity with all 1G/10G ports (all ports, full duplex): 168 Gb/s
n. Switch frame rate with 6 x 10GE ports @ 64-byte packet: 125 Mpps
o. 2x10GE stacking capacity (aggregated): 40 Gb/s
p. System Power Consumption: 40W
q. System heat dissipation: 143 (BTU/h)
r. Power Consumption w/PoE: 600W
s. Heat dissipation w/PoE: 2047 (BTU/h)
t. Dimensions (WxDxH): 17.33” x 13.78” x 1.73”
u. Weight: 10.75 lbs. (4.88 kg)
v. Operating Temperature: (Min) 32°F – (Max) 113°F [(Min) 0°C – (Max) 45°C]
w. Operating Humidity: 5 – 95% Non-condensing
x. Power Supply: Modular 920W AC PoE
y. PoE with 1 PSU: Up to 815W
z. PoE with 2 PSU: Up to 1645W

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aa. Power Supply Input voltage/current: 90V to 136V AC/13A, 180V to 264V AC/6.5A
bb. Power Supply Max output power/current: 920W/16.88A
cc. Power Supply efficiency: 89%

D. 48-port Layer 2/3 PoE Switches:

1. The Layer 2/3 PoE switches shall include the following features:

a. Gigabit RJ-45 port count: 48 PoE+
b. 1G SFP+ port count: 2
c. 1G/10G SFP+: 4
d. MACSec capable ports: All 1G RJ45, 2 x 1G SFP, 2 x 10 SFP+
e. USB port: 1
f. Console port: 1
g. Primary slide-in PSU slot: 1
h. Backup slide-in PSU slot: 1
i. Fans: 2
j. File system flash: 2GB
k. RAM: 1GB
l. Max switching ASIC capacity: 216 Gb/s
m. Switch capacity with all 1G/10G ports (all ports, full duplex): 216 Gb/s
n. Switch frame rate with 6 x 10GE ports @ 64-byte packet: 160.5 Mpps
o. 2x10GE stacking capacity (aggregated): 40 Gb/s
p. System Power Consumption: 104W
q. System heat dissipation: 355 (BTU/h)
r. Power Consumption w/PoE: 920W
s. Heat dissipation w/PoE: 3139 (BTU/h)
t. Dimensions (WxDxH): 17.33” x 13.78” x 1.73”
u. Weight: 10.3 lbs. (4.68 kg)
v. Operating Temperature: (Min) 32°F – (Max) 113°F [(Min) 0°C – (Max) 45°C]
w. Operating Humidity: 5 – 95% Non-condensing
x. Power Supply: Modular 920W AC PoE
y. PoE with 1 PSU: Up to 815W
z. PoE with 2 PSU: Up to 1645W
aa. Power Supply Input voltage/current: 90V to 136V AC/13A, 180V to 264V AC/6.5A
bb. Power Supply Max output power/current: 920W/16.88A
cc. Power Supply efficiency: 89%

E. Self-Managed Switch:

1. SSI shall provide 6-port switches to support site-located PoE equipment at gate control locations. The switches shall include the following features:

a. Data Rate: 10/100/1000 Mbps IEEE 802.3 Compliant, Full Duplex or Half Duplex Electrical Ports/Full Duplex Optical Port
b. Electrical: Ports 1 - 4: 30W Max
c. Optical Connectors: Requires SFP-SX modules
d. Physical characteristics (cm): 15.5 x 13.5 x 2.8
e. Weight:0.9 kg

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f. Operating Voltage: 48 to 57 VDC PoE, 12 to 24 VDC non-PoE
g. Current Draw: 5A max, with PoE, 1A w/o PoE
h. Operating temperature: -40°C to 75°C
i. Operating relative humidity: 0% to 95%, noncondensing
j. Mounting: Wall or Flat Surface Screw Attachment
k. Approved manufacturer: Comnet CNGE2FE4SMSPoE
l. Provide Comnet Power Supply model PS48VDC-5ADIN, or approved equal

2.10 VIDEO CLIENT WORKSTATIONS

A. Manufacturers:

1. Dell
2. HP

B. Description: Video client workstations and monitors shall be provided at GUI control station locations to allow the operator(s) to view cameras around the facility. Reference Section 1.2 for workstation and monitor quantities, locations and sizes. SSI shall coordinate the exact location of the workstations and monitors with the Architect, Owner and other trades as necessary. Each workstation shall be loaded with the VMS software. The basis for the specification is Dell.

C. Video Client Workstations:

1. The Video Client Workstations shall include the following (minimum) features:

a. Processor: Intel® Core™ i7-10700, 8 Core, 16MB Cache
b. Operating System: Windows 10 Professional, 64-bit
c. Memory: 16GB
d. Hard Drive: 512GB SSD
e. Video Card: NVIDIA Quadro P620 (2GB) (for use with single monitor applications)
f. Video Card: NVIDIA Quadro P1000 (4GB) (for use with dual monitor applications)
g. Keyboard: Dell USB Keyboard, English, Black
h. Mouse: Dell USB Optical Mouse with Scroll, Black
i. 24” Monitor; Dell model E2420H
j. 27” Monitor (4K); Dell model U2721Q
k. 43” Monitor (4K); Samsung model UN43TU8000FXZA
l. 50” Monitor (4K); Samsung model UN50TU8000FXZA

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances. SSI shall confirm that no obstructions exist that would obstruct camera views.

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B. Comply with manufacturer's installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

C. Precautions shall be taken to guard against electrostatic and electromagnetic susceptibility and interference.

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

3.2 INSTALLATION

A. Provide complete IP video communication system as specified herein.

B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

C. All VMS head-end equipment to be contained within equipment racks.

D. Provide adequate ventilation for all heat radiating equipment. SSI shall provide fan kits as required to maintain rated operating temperature of installed equipment.

E. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

F. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

G. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

H. Wires shall not be nicked, have strands removed, or have frayed strands when removing insulation or terminating.

I. Cameras located in rooms with small footprints (sally ports, holding rooms, etc.) shall be ceiling-mounted and shall be near vertical walls to maximize the field of view.

J. Seal-tite flexible conduits, NEMA-rated weatherproof junction boxes connectors shall be utilized for exterior camera locations.

3.3 CONNECTIONS

A. All IP video communication system equipment connections shall be completed per manufacturer's recommendations and per SSI shop drawings.

B. Ground equipment according to manufacturer's recommendations.

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3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust IP video communication system 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 pass/fail reports:

1. Video image inspection: SSI shall perform a visual inspection of each video image to ensure that each camera is properly focused, aimed, and properly configured for its location.
2. Video client PCs shall be initially configured for camera views applicable to their areas, coordinated with the Owner, and tested for proper operation.

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

3.5 ADJUSTING

A. All cameras shall be adjusted for optimum performance.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four visits to Project for this purpose.

3.6 DEMONSTRATION

A. Provide qualified personnel to train Owner's maintenance personnel to adjust, operate, and maintain the IP video communication system. Refer to Division 01 Section "Demonstration and Training."

B. Training shall be video recorded.

END OF SECTION 28 23 20

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SECTION 28 31 00 ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section provides for a new fire alarm system to be installed and fully functional in this correction facility.

B. Fire alarm devices installed within inmate accessible areas as identified in the architectural documents shall be suitable for Institutional Group I-3 occupancy.

C. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Fire Alarm Device protective covers.
8. Remote annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.
11. Network communications.

D. This facility shall be divided up into individual notification and detection circuits as follows.

1. POD Inmate area.
2. POD Control tower.
3. POD mechanical spaces.
4. Connecting Corridor and mechanical spaces.
5. Connecting Corridor intake and booking.
6. Sheriff Administration
7. Kitchen and Laundry

E. Related Requirements:

1. Section 087100 - Door Hardware: Door closers, electric locks, electric releases.
2. Section 211200 - Fire-Suppression Standpipes: Flow detection and alarm devices.
3. Section 212200 – Clean Agent Extinguishing System
4. Section 211313 - Wet-Pipe Sprinkler Systems: Flow detection and alarm devices.

5. Section 233300 - Air Duct Accessories: Smoke dampers: HVAC duct dampers and instrumentation.
6. system to supervise fire and smoke alarms, as well as other building systems.
7. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Building wire and cable.
8. Section 260526 - Grounding and Bonding for Electrical Systems: Grounding and bonding of fire-alarm equipment and circuits.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. LED: Light Emitting Diode

D. NICET: National Institute for Certification in Engineering Technologies.

E. NFPA 72 apply to fire alarm terms used in this Section.

F. FANP: Fire Alarm Power Extender Panel.

G. FAAP: Fire Alarm Annunciator (LCD).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. System operation description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
2. System riser diagram with device addresses, conduit sizes, and cable and wire types and sizes.
3. Wiring diagrams: Power, signal, and control wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Show wiring color code.

4. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
5. Include plans, elevations, sections, details, and attachments to other work.
6. 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.

7. Detail assembly and support requirements.
8. Include voltage drop calculations for notification-appliance circuits.
9. Include battery-size calculations.
10. Include input/output matrix.
11. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
12. Include performance parameters and installation details for each detector.
13. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
14. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
15. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
    d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    e. Locate detectors according to manufacturer's written recommendations.
    f. Show air-sampling detector pipe routing.

16. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
17. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III minimum.
    c. Licensed or certified by authorities having jurisdiction.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. Include the following and deliver copies to authorities having jurisdiction:

    a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 EXTRA MATERIAL

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: **Ten**
2. Lamps for Strobe Units: **Ten**
3. Smoke Detectors: **Ten**
4. Detector Bases: **Five**
5. Keys and Tools: One extra set for access to locked or tamper proofed components.
6. Audible and Visual Notification Appliances: [**One**] of each type installed.
7. Fuses: [**Two**] of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
8. Filters for Air-Sampling Detectors: Quantity equal to [**two**] percent of amount of each type installed, but no fewer than one unit of each type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm [**Level III**] technician.

C. Requirement of Regulatory Agencies:

1. National Fire Protection Association (NFPA).
   a. NFPA 70 National Electrical Code.
   b. NFPA 72 National Fire Alarm Code.
   c. NFPA 90A Standard for the installation of Air Conditioning and Venting Systems.
   d. NFPA 92 Standard for Smoke Management Systems.
   e. NFPA 101 Life Safety Code.

2. Underwriters Laboratories, Inc. (UL)WARRANTY

   a. UL 864, 10th Edition.
   b. UL FPED.
   c. UL 1971, standard for visual signaling appliances. Uniform Building Code and the Uniform Fire Code or other State and Local Building Codes as adopted and/or amended by the authority having jurisdiction.
   d. Department of Justice rules for building accessibility by the handicapped, and/or State and local equivalency standards as adopted by local AHJ's

D. Manufacturer's Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: [**one**] year from date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTUERS

A. Fire alarm systems, equipment, hardware and software shall be provided by a single manufacturer.

B. Manufacturers: Subject to compliance with requirements of this section and sections referenced in paragraph, provide products by one of the following:

1. FACP, Audible and Visual Signals, and Equipment
   a. EST
   b. NOTIFIER.
   c. Siemens Building Technologies, Inc.; a Cerberus Division.
   d. JCI/ Simplex

2. Wire and Cable
    a. Comtran Corporation.
    b. Helix/HiTemp Cables, Inc.; a Draka USA Company.
    c. West Penn Wire/CDT; a division of Cable Design Technologies.

2.2 SYSTEM DESCRIPTION

A. Non-code, analog-addressable system; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only. System shall be forward and backward compatible without replacing or extensive modifications for ten (10) years.

1. The system shall include all required hardware, interconnecting wiring and software to accomplish the requirements of this specification section and the contract documents for complete operational system.
2. The system shall be UL 864 – 10th Edition compliant and meet the requirements of UOJZ for Fire Alarm Control and also meet UUKL for Smoke Control in accordance with NFPA 90A and 92. The system shall be listed and approved for use in both dedicated and non-dedicated smoke control.
3. All components provided shall be listed for use with the selected system.

2.3 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices [**and systems**]:

1. Manual stations.
2. Heat detectors.
3. Flame detectors.
4. Smoke detectors.
5. Duct smoke detectors.
6. Air-sampling smoke-detection system
7. Combustible gas detectors.
8. Automatic sprinkler system water flow.
9. Fire-extinguishing system operation.
10. Clean Agent Extinguishing System flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the 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 heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.

10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Recall elevators to primary.
12. Activate elevator power shunt trip.
13. Activate emergency lighting control.
14. Activate emergency shutoffs for gas and fuel supplies.
15. Record events in the system memory.
16. Record events by the system printer.
17. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Alert and Action signals of air-sampling detector system.
3. Elevator shunt-trip supervision.
4. Independent fire-detection and -suppression systems.
5. User disabling of zones or individual devices.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at the FACP and FAAP.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at the FACP and FAAP.
10. Voice signal amplifier failure.
11. Low-air-pressure switch operation on pre-action sprinkler system
12. Removal of an alarm initiating device.
13. Loss of power to equipment and components required to perform a required fire safety function.
14. Trouble in any fire suppression system control panel such as pre-action or gas systems.
15. Failure in remote fire alarm notification appliance circuit power supplies.
16. Failure in air sampling detectors and associated power supplies

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at FACP and FAAP.
3. Record the event on system printer.
4. Transmit system status to building management system.
5. Display system status on graphic annunciator.

2.4 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

    a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
    b. Include a real-time clock for time annotation of events on the event recorder and printer.
    c. Provide communication between the FACP, FAAP and remote circuit interface panels, annunciators, and displays.
    d. The FACP shall be listed for connection to a central-station signaling system service.
    e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 4000-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and control menu.

1. Annunciator and Display: Liquid-crystal type, [**160**] characters, minimum.
2. Keypad: Arranged to permit entry and execution of display, and control commands.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, [**four**] lines of [**40**] characters, minimum.
2. Keypad: Arranged to permit entry and execution of display, and control commands.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, [**Class C**]
2. Pathway Survivability: [**Level 1**].
3. Serial Interfaces:

    a. One dedicated RS 485 port for [**central-station**] [**remote station**] operation using point ID DACT.

b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
c. One Ethernet port for PC configuration.

E. Stairwell and Elevator Shaft Pressurization: Provide an output signal using an addressable relay to start the stairwell and elevator shaft pressurization system. Signal shall remain on until alarm conditions are cleared, and fire-alarm system is reset. Signal shall not stop in response to alarm acknowledge or signal silence commands.

1. Pressurization starts when any alarm is received at fire-alarm control unit.
2. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.

F. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

G. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

H. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

a. Elevator lobby detectors except the lobby detector on the designated floor.
b. Smoke detector in elevator machine room.
c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Voice/Alarm Signaling Service: Central emergency communication system

1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.

a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
b. Programmable tone and message sequence selection.
c. Standard digitally recorded messages for "Evacuation" and "All Clear."
d. 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 fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.

L. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, [**supervisory signals**] [**supervisory and digital alarm communicator transmitters**] be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall 8not exceed 80 percent of the power-supply module rating.

M. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead-acid of nickel cadmium type. Provide sufficient capacity to operate the complete system in normal or supervisory (non-alarm) mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all components of the system, including all alarm indicating devices in alarm or supervisory mode for a period of 5 minutes.

N. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 MANUAL FIRE-ALARM BOXES (Manual Pull Stations)

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be die-cast construction finished in red with operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, [**lift-cover**] [**pull-lever**] type; with [**integral**] addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
2. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
4. Integral Visual-Indicating Light: LED type, indicating detector has operated.
5. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition **and individually adjustable for sensitivity by fire-alarm control unit**.

    a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 deg F (8 deg C) per minute.
    b. Multiple levels of detection sensitivity for each sensor.
    c. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with NFPA 72.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
4. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 PROJECTED BEAM SMOKE DETECTORS

A. Projected Beam Light Source and Receiver: Designed to accommodate small angular movements and continue to operate and not cause nuisance alarms.

B. Conventional detector with monitor module to identify the detector's location within the system.

2.8 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with NFPA 72.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of [**135 deg F (57 deg C)**] or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Continuous Linear Heat-Detector System:

1. Detector Cable: Rated detection temperature [**155 deg F (68 deg C)**]. Listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short circuit wires at the location of elevated temperature.
2. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
3. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone

shall be individually reported to central fire-alarm control unit as separately identified zones.

4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.9 AIR-SAMPLING SMOKE DETECTOR

A. General Description:

1. Air-sampling smoke detector shall be laser based using a piping system and a fan to transport the particles of combustion to the detector.
2. Provide two levels of alarm from each zone covered by the detector and two supervisory levels of alarm from each detector.
3. The air being sampled shall pass through filters to remove dust particulates greater than 20 microns before entering the detection chamber.
4. Detectors shall have the capability via RS 485 to connect up to 100 detectors in a network.
5. Detectors shall communicate with the fire-alarm control unit via addressable, monitored dry contact closures, RS 485, and interface modules. Provide a minimum of six relays, individually programmable remotely for any function.
6. Pipe airflow balancing calculations shall be performed using approved calculation software.

B. Detector:

1. Detector, Filter, Aspirator, and Relays: Housed in a mounting box and arranged in such a way that air is drawn from the detection area and a sample passed through the dual-stage filter and detector by the aspirator.
2. Four independent, field-programmable, smoke-alarm thresholds per sensor pipe and a programmable scan time delay. The threshold set points shall be programmable.

    a. The four alarm thresholds may be used as follows:

        1) Alarm Level 1 (Alert): Activate a visual and an audible supervisory alarm.
        2) Alarm Level 2 (Action): Activate shutdown of electrical/HVAC equipment and activate a visual and an audible supervisory alarm.
        3) Alarm Level 3 (Fire 1): Activate building alarm systems and initiate call to fire response unit.
        4) Alarm Level 4 (Fire 2): Activate suppression system or other countermeasures.

    b. Final Detection System Settings: Approved by **Owner**.

3. Power Supply:

    a. Regulated 24-V dc, monitored by the fire-alarm control unit, with battery backup.
    b. Battery backup shall provide 24 hours' standby, followed by 30 minutes at maximum connected load.

4. Detector shall also transmit the following faults:

a. Detector.
b. Airflow.
c. Filter.
d. System.
e. Zone.
f. Network.
g. Power.

5. Provide four in-line sample pipe inlets that shall contain a flow sensor for each pipe inlet. The detector shall be capable of identifying the pipe from which smoke was detected.
6. Aspirator: Air pump capable of allowing for multiple sampling pipe runs up to 650 feet (200 m) in total, (four pipe runs per detector) with a transport time of less than 120 seconds from the farthest sample port.
7. Air-Sampling Flow Rates Outside Manufacturer's Specified Range: Result in a trouble alarm.
8. Provide software-programmable relays rated at 2 A at 30-V dc for alarm and fault conditions.
9. Provide built-in event and smoke logging; store smoke levels, alarm conditions, operator actions, and faults with date and time of each event. Each detector (zone) shall be capable of storing up to 18,000 events.
10. Urgent and Minor Faults. Minor faults shall be designated as trouble alarms. Urgent faults, which indicate the unit may not be able to detect smoke, shall be designated as supervisory alarms.

C. Displays:

1. Include display module within each detector.
2. Each display shall provide the following features at a minimum:

a. A bar-graph display.
b. Four independent, high-intensity alarm indicators (Alert, Action, Fire 1, and Fire 2), corresponding to the four alarm thresholds of the indicated sector.
c. Alarm threshold indicators for Alert, Action, and Fire 1.
d. LED indication that the first alarm sector is established.
e. Detector fault and airflow fault indicators.
f. LED indicators shall be provided for faults originating in the particular zone (Zone Fault), faults produced by the overall smoke-detection system, and faults resulting from network wiring errors (Network Fault).
g. Minor and urgent LED fault indicators.

D. Sampling Tubes:

1. Smooth bore with a nominal 1-inch (25-mm) OD and a 7/8-inch (21-mm) ID. Sampling pipe with between 5/8- and 1-inch (15- and 25-mm) ID can be used in specifically approved locations when recommended by manufacturer.
2. Pipe Material: CPVC and complying with UL 1887, "Safety Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics."
3. Joints in the sampling pipe shall be airtight. Use solvent cement approved by the pipe manufacturer on all joints except at entry to the detector.
4. Identify piping with labels reading: "Aspirating Smoke Detector Pipe - Do Not Paint or Disturb" along its entire length at regular intervals according to NFPA 72.

5. Support pipes at not more than 60-inch (1520-mm) centers.
6. Fit end of each trunk or branch pipe with an end cap and drilled with a hole appropriately sized to achieve the performance as specified and as calculated by the system design.

E. Sampling Holes:

1. Sampling holes of 5/64 inch (2 mm), or other sized holes per manufacturer's written instructions, shall be separated by not more than the maximum distance allowable for conventional smoke detectors. Intervals may vary according to calculations.
2. Follow manufacturer's written recommendations to determine the number and spacing of sampling points and the distance from sampling points to ceiling or roof structure and to forced ventilation systems.
3. Each sampling point shall be identified by an applied decal.

2.10 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear lens mounted on an aluminum faceplate. The word "FIRE" is displayed in minimum 1-inch- (25-mm-) high letters.

1. Rated Light Output:

a. 15/30/75/110 candela, selectable in the field

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, **red.**

C. Voice/Tone Notification Appliances:

1. Comply with UL 1480.
2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
3. High-Range Units: Rated 2 to 15 W.
4. Low-Range Units: Rated 1 to 2 W.
5. Mounting: **Flush**, **semi-recessed**] [**or**] **surface mounted and bidirectional**.
6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

D. Exit Marking Audible Notification Appliance:

1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.
2. Provide exit marking audible notification appliances at the entrance to all building exits.
3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

2.11 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unit and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:

1. Common-talk type for firefighter use only.
2. Selective-talk type for use by firefighters and fire wardens.
3. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is taken off the hook, it causes an audible signal to sound and a high-intensity lamp to flash at the fire command center.
4. Selector panel controls to provide for simultaneous operation of up to five telephones in the same zone. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
5. Display: LED to indicate location of caller.
6. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
7. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Emergency Phone."

2.12 FIREFIGHTERS' SMOKE-CONTROL SYSTEM

A. Initiate Smoke-Management Sequence of Operation:

1. Comply with sequence of operation as described in Section 230993.11 "Sequence of Operations for HVAC DDC."
2. Smoke control panel shall provide all interfaces and control points required to properly activate smoke-management systems.
3. First fire-alarm system initiating device to go into alarm condition shall activate the smoke-control functions.
4. Subsequent devices going into alarm condition shall have no effect on the smoke-control mode.

2.13 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: [**Surface**] cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.14 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal [**to elevator controller to initiate elevator recall**].

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of one normally open and one normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

2.15 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture [**two**] telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.16 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

2.17 FIRE ALARM DEVICE PROTECTIVE COVERS

A. Description: Provide Safety Technology International (STI) type protective covers for the manual pull station, smoke detector, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.

2.18 WIRE AND CABLE

A. Wire and cable for fire alarm systems shall be UL listed and labeled as complying with NFPA 70, Article 760.

B. Signaling Line Circuits: Type and size as recommended by system manufacturer.

C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

1. Low-voltage circuits: No. 16 AWG, minimum.
2. Line-voltage circuits: No. 12 AWG, minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Equipment Mounting: Install fire-alarm control unit on concrete base. Comply with requirements for concrete base specified in **Section 033000 "Cast-in-Place Concrete."**

C.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (460-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.

3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

F. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed [**30 feet (9 m)**] .
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A **or Annex B** in NFPA 72.
5. HVAC: Locate detectors not closer than [**36 inches (910 mm)**] from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

G. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

H. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

I. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.

J. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

K. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

L. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

M. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

N. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

O. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated HVAC duct systems.
4. Electronically locked doors and access gates.
5. Alarm-initiating connection to elevator recall system and components.
6. Alarm-initiating connection to activate emergency lighting control.
7. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
8. Supervisory connections at valve supervisory switches.
9. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
10. Supervisory connections at elevator shunt-trip breaker.
11. Data communication circuits for connection to building management system.
12. Supervisory connections at fire-extinguisher locations.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

C. Perform the following tests and inspections **with the assistance of a factory-authorized service representative**:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify the 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.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include [**12**] months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall 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 shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least [**60**] days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION AND TRAINING

1. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner and/or Owner's Representative. Provide competent, factory authored personnel to provide instruction to operation and maintenance personnel concerning the location, operation and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner and/or Owner's Representative after submission and approval of formal training plans.

2. Train Owner’s maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventative maintenance of the system. Provide a minimum of eight (8) hours’ training.

3. Schedule training with the Owner at least seven days in advance.

END OF SECTION 28 31 00

SECTION 28 35 00 REQUIREMENTS FOR ELECTRONIC SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, general provisions of the Contract, including General and Supplementary Conditions, and Division-1 Specification Sections and other Division-26/28 Specification Sections, apply to work of this Section.

B. Drawings and general provisions of the Contract, including General Conditions, Amendments to the General Conditions and Division-1 Specification Sections, apply to this and other Sections of Division-26/28.

C. Related Sections:

1. Section 26 01 00 - Basic Electrical Requirements

2. Section 26 27 26 - Wiring Devices

1.2 SUMMARY

A. Electronic Systems raceway, cables and equipment shall be installed in accordance with these specifications. The Electrical Contractor and the Electronic Systems Contactor(s) shall cooperate to provide complete and operable systems as specified in the related sections of these specifications.

1. Telephone Systems

2. Television Systems

3. Data

4. Security System

5. Access and Control Systems

6. Temperature controls systems

7. Fire alarm system

B. The Electrical Contractor (Div 26) shall be responsible for the following:

1. Furnishing and installing all conduit, cabling, outlet and junction boxes, etc., as required for a complete raceway system.

2. Providing and pulling all system required cables, testing all cables, installing systems devices, terminating cables at the device and properly tagging all electronic systems cables with identifying addresses as supplied by the Electronic Systems Contactor(s).

3. Providing complete set of A/E prepared bid documents (drawings, specs, and addenda) to the Electronic Systems Contractor for the ESC's use in preparation of shop drawings and rough-in prints, when the ESC is a supplier/subcontractor to the Electrical Contractor.

C. The Electronic Systems Contractor(s) shall be responsible for the following:

1. Preassembling of all headend equipment, racks, and required cabinets and delivering them to the site.

2. Area 'A' only - Furnishing all devices and equipment Installing and making final connections to all electronic systems head end equipment.

3. Area 'B' only - Furnishing all devices and equipment. Providing installation coordination to Div 26 for Div 26's installation and terminations of all devices, cabling and headend equipment.

4. Supplying all electronic systems cables requirements to the Electrical Contractor and directing the installation of those cables for Div 26 to purchase and install

5. Performing all systems tests and making all adjustment as hereinafter specified for individual systems, utilizing ESC owned instruments on which ESC personnel are thoroughly trained.

6. Warranty all equipment and systems as required in Section 26 01 00, "Basic Electrical Requirements."

1.3 SUBMITTALS

A. The Electrical Contractor shall submit manufacturer's data and shop drawings for raceway systems components and materials supplied by him as required in Section 26 01 00, "Basic Electrical Requirements" and as required in related sections of these specifications.

B. The Electronic Systems Contractor(s) shall submit manufacturer's data, shop drawings and wiring diagrams for all electronic systems components and materials supplied by him as required in Section 26 01 00, "Basic Electrical Requirements" including the following:

1. Product data for each type of product specified including dimensioned plans, sections, and elevations showing minimum clearance, installed features and devices, and a list of materials.

2. Shop drawings shall include scaled plans and component locations with interconnecting wiring indicated.

3. Wiring diagrams, detailing wiring for power, signal, and control, differentiating clearly between manufacturer-installed wiring and field-installed wiring. Identify terminals to facilitate installation, operation and maintenance.

4. Maintenance data for materials and products, for inclusion in Operating and Maintenance Manuals specified in Section 26 01 00, "Basic Electrical Requirements."

5. Coordinating drawings for detailing major elements, components and wiring raceways in relationship with other systems, installation and building components as specified in Section 26 01 00, "Basic Electrical Requirements."

6. Training for the Owner's representative(s) in the operation of each system as specified in Section 26 01 00, "Basic Electrical Requirements."

1.4 QUALITY ASSURANCE

A. Materials furnished as a part of these systems shall comply with the specific requirements for those materials in related sections of the Division-26/28 Specifications.

B. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 "National Electrical Code" including, but not limited to:

1. Article 250, Grounding

2. Article 300, Part A. Wiring Method

3. Article 310, Conductors for General Wiring

4. Article 725, Remote Control, Signaling Circuits

5. Article 800, Communication Systems

C. TIA/EIA Compliance: The telephone and data systems wiring and devices shall be installed in accordance with the following:

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle materials as required in Section 26 01 00, “Basic Electrical Requirements.”

1.6 SEQUENCES AND SCHEDULING

A. The Electrical Contractor and the Electronic Systems Contractor(s) shall coordinate their work with each other and with other Work, including General and Mechanical, to properly interface installation of electronic systems and raceway with that work.

B. Sequence the installation of electronic systems and raceways with other work to minimize the possibility of damage and soiling during the remainder of construction.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

Mfg/	**Description**
Corning, Optical Cable Corp.	Fiber Box
Corning, Optical Cable Corp.	6 strand MM Module
Panduit, Leviton, Hubbell	48 port plastic patch panel - open
Panduit, Leviton, Hubbell	24 port voice patch to rj21
Panduit, Leviton, Hubbell	vertical cable mgmt
Panduit, Leviton, Hubbell	horizontal cable mgmt
Panduit, Leviton, Hubbell	19" 20 amp rackmount pdu
Panduit, Leviton, Hubbell	cat6 jacks ivory
Panduit, Leviton, Hubbell	6 outlet wall plates
Panduit, Leviton, Hubbell	ultimate id icons - data pkg 100
Panduit, Leviton, Hubbell	ultimate id icons - phone pkg 100
Panduit, Leviton, Hubbell	19" 45u relay rack
Belden, AT&T, General Cable	1000' cat6 yellow riser data twist

B. Raceway Systems

1. Provide products by one or more of the manufacturers listed in related sections of these Division-26/28 Specifications for each specific component or assembly.

2.2 MATERIALS – GENERAL

A. These specifications contemplate a complete and operable system for each electronic system provided. Although each and every minor electronics item required for complete and operative systems may not be specifically mentioned herein or shown on the drawings, it shall be the Electronic Systems Contractor's responsibility to provide and complete the same.

B. Manufacturer's model numbers listed in the various electronic systems are shown as a basis of minimum standards and performance required. Equipment or other manufacturers will be considered only if judged by the Engineer to be equal to or superior to the specified items in all respects as to quality and performance. Features, functions, and performance shall remain the same regardless of equipment manufacturer. (Should any model number be obsolete or superseded, it shall be understood that the newest equivalent model shall be furnished.) Refer to Section 26 01 00, "Basic Electrical Requirements" for requesting approval of additional manufacturers' products.

C. The Electronic Systems Contractor shall be the local authorized distributor of equipment supplied and shall maintain a local service department, stock sufficient replacement parts, and be authorized to provide factory-warranty service.

2.3 CONDUIT AND RACEWAY REQUIREMENTS

A. A raceway system shall be provided from outlet boxes to above accessible, lay-in ceilings. Cables may be installed exposed above accessible ceilings. Provide conduit in walls, under floors and above drywall, plaster or other non-accessible ceilings. Provide sleeves through firewalls, or other walls which extend to the structure and through floors as required to route exposed cables to the terminal equipment.

B. Conduit Size

1. The smallest size conduit used for any electronic system shall be 3/4". Where cables are grouped and routed together, size conduit as indicated on the drawings or as directed by the Electronic Systems Contractor. Install conduits with a minimum bending radius of 6". The electrical contractor shall coordinate with all systems contractor's requirements so to provide all required boxes, conduits and raceways. Only where appropriate or required for proper functioning provide multiple raceway, otherwise consolidate raceways as appropriate. Life safety systems devices and cables shall not share boxes nor conduits with other non-life safety systems.

C. Sleeves

1. Where sleeves are required for routing exposed cables, provide separate sleeves for each system. Sleeves shall be a minimum of 2" and sized for all required cables plus 10 percent (minimum of 1). The Electronic System Contractor shall

be responsible for determining the proper size sleeves and advising the Electrical Contractor who is responsible for installing the proper size sleeves.

D. Pull Boxes

1. Provide a pull box in all conduit runs so that no conduit run exceeds 100 linear feet or has more than two quarter bends (180 degrees, total).

E. Wall Plates

1. Provide wall plates to mount outlets and devices as required in the section on "Wiring Devices" for each wall outlet. Provide blank plates for unused outlets. All plates shall match in size, and shall be Stainless Steel with tamper resistant hardware.

F. Pull Wires

1. All empty conduit for future use shall be provided with a #14 AWG galvanized steel pull wire or a nylon pull cord of equivalent strength.

2.4 CABLES

A. General Requirements

1. Provide cables which are suitable for the specific use. Descriptions are for general use cables. The equivalent plenum rated, riser rated cables shall be provided as required in NEC Article 725, for those applications.

2.5 DATA CABLES

A. Where requirements are not called out elsewhere, Category 6 cable shall be a 22 AWG, 4 pair unshielded cable which has transmission characteristics suitable for data rates above 16 Mbps. Cable shall meet the requirements for Category 6 cable defined by EIA/TIA.

2.6 FIBER OPTIC CABLES

A. Where requirements are not called out elsewhere, Fiber optic cable shall be six strand 62.5/125 type cable with the following specifications:

Core diameter:	62.5 +/- 2.5 micron
Cladding diameter:	125.0 +/1 2.0 micron
Core concentricity:	5% maximum
Refractive index delta:	20% maximum
Numeral sperture:	0.29
Attenuation range:	3.6 – 4.6 dB/Km at825 rm
Mean deviation:	0.15 dB
Bandwidth range:	200 MHz – Km, minimum
Typical splice loss:	0.15 dB (array); 0.28 dB (fusion)
Coating diameter:	245 +/- 20 micron

2.7 TELEPHONE SYSTEM CABLES

A. Individual outlets shall be wired with a cable of 22 AWG, 4 pair solid copper, unshielded, twisted pair construction in a polyvinyl chloride sheath. Cable shall conform to Insulated Cable Engineers Association (ICEA) Standard S-80-576 and EIA/TIA-568 Standard Category 6.

2.8 TELEVISION SYSTEM CABLES

A. Television system cables shall be 75 ohm nominal impedance coaxial cable which have been 100 percent factory sweep tested from 5 to 850 MHz by the structural return loss method. The following types are included:

1. Analog or Digital Video Coax: RG 6, nom.comacitance: 16.2 PF/FT, cellular polyethylene dielectric, bare copper braid shield with 95 percent minimum shielding factor, No. 18 AWG solid copper conductor and PVC jacket.

2.9 TERMINATIONS, CONNECTORS AND DEVICES

A. General Requirements

1. Provide terminations, connectors and devices which are suitable for the specific use on each system.

B. Data

1. Wall outlets shall be RJ45, Category 6 modular jack type outlets.

C. Telephone Systems

1. Wall outlets shall be RJ45 modular receptacles.

D. Television Systems

1. CATV Coaxial Cable Connectors: Type F, 75 ohms.

PART 3 – EXECUTION

3.1 INSTALLATION, GENERAL

A. The Electronic Systems Contractor shall identify originations and destinations for all cable runs to Div 26 where Div 26 is terminating cables.

B. The Electrical Contractor shall leave a minimum of two (2) feet wire tails at each outlet, four (4) feet wire tails at each terminal cabinet and fifteen (15) feet at terminal boards, equipment racks, housings or consoles. (This only applies where the electrical contractor is not providing the terminations.)

C. Materials furnished as a part of these electronic systems and raceways shall comply with the specific requirements for those materials set forth in this and in related sections of these Division-26/28 Specifications.

D. Both the Electrical Contractor and the Electronic Systems Contractor shall examine the areas and conditions under which the raceway systems and electronic systems are to be installed. They shall notify the Architect/Engineer, in writing, of any conditions which may be detrimental to the installation, operation or maintenance of equipment and cables. Work shall not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the Installing Contractor.

3.2 WIRING INSTALLATION

Refer to Conduit and Raceway Requirements for approved wiring methods.

A. Install wiring of power-limited circuits in raceways except that open cables may be routed above accessible ceilings. Provide plenum rated cables in all HVAC air plenum areas and riser rated cables as required in NEC Article 725. Use conduit for all cable through floors, exposed, in shaftways, and in walls.

B. Plenum, riser and open cables (where used) shall be bundled, tied and connected to building structure, with nylon tie-wrap of at least 30 pounds tensile strength, on a maximum of 4 feet spacing. Do not install laid on ceiling grids, on ceilings, or tied to ceiling grid support wires.

C. All electronic cables shall be neatly secured with nylon tie-wraps at not more than 4” intervals. Cables shall be labeled with Brady, or approved equivalent, labels at each end as to circuit designations.

D. Telephone and data systems cables shall be installed in accordance with the recommendations of TIA/EIA for structured cabling. Terminate all pairs of each cable. Do not “split wire” two outlets to one cable. Limit horizontal cabling to 300 feet total length. Terminate cabling in a closet as the area served unless specifically noted otherwise on the drawings. Do not tightly cinch cable bundles and otherwise avoid stress or tension on the cables.

1. Terminate cables on 8 position jack pin/pair assignment in accordance with TIA/ETA-568-B2.

E. AC wiring to convenience outlets within electronics equipment racks shall be installed in conduit in accordance with the latest National Electrical Code, including all supplements. All plugs and receptacles used shall be of the grounding type.

F. No splices (joints) in electronics wiring will be permitted except in terminal cabinets or equipment housings, (i.e., no splicing is permitted in pull boxes).

G. Conduit provided for all electronics cables shall be sized for a maximum fill of 40 percent of the internal area of the conduit. The Electronic System Contractor shall be responsible for assuring that the conduit sizes indicated on the drawings are sufficiently large for the particular cables to be used and shall be responsible for advising the

Electrical Contractor of any necessary increases in size. The Electronic Systems Contractor shall be responsible for any additional costs required to provide any such increases in size not included in the original contract prices.

3.3 EQUIPMENT INSTALLATION

A. Devices shall be installed in quantity and locations indicated on the drawings. Where units are mounted in wall boxes, provide a wall plate as specific for electrical devices.

B. Electronic equipment shall be mounted securely to walls or columns, and the Electrical Contractor shall provide all necessary brackets, mounting devices, structural pieces and expansion type anchor inserts necessary for this purpose. Apparatus shall not be mounted directly to concrete or masonry walls. Structural channels shall be used to mount said apparatus at least 3/4 inch away from concrete or masonry walls.

C. All electronics installation shall be made by skilled communications technicians during regular working hours and concurrent with the progress of other trades, such that all installations will be substantially completed at the same time.

3.4 GROUNDING

A. Unipoint grounding technique shall be employed: All grounding of electronics systems shall be made at the main equipment; the conduit system, building structural system, or building piping systems shall not be used for ground return. The Electrical Contractor shall furnish and install a 6 AWG (minimum) insulted grounding electrode conductor in 3/4 inch PVC to the nearest available effectively grounded structural member, the grounding electrode system, or nearest available effectively grounded metal domestic water pipe. Grounding conductor to be terminated in the equipment racks and housing as directed by the Electronic Systems Contractor.

3.5 FIELD QUALITY CONTROL

A. Upon completion of the installation of raceway systems, inspect interiors of raceways; clear all blockages and remove burrs, dirt and construction debris.

B. Touch-up scratched or marred enclosure surfaces to match original finishes.

C. Protect installed equipment and components from damage during the remainder of the construction period.

3.6 CHECK, TEST AND START-UP

A. Electronic systems connection, set-up, testing and final performance shall be the sole responsibility of the Electronic Systems Contractor(s). Systems shall be tested and demonstrated to equal or exceed the specified system criteria.

B. Pretesting: Upon completing installation of the system, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items

with new and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

C. Report of pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable. The letter shall include the names and titles of the witnesses to the preliminary tests.

D. Final test notice: Provide 10 days minimum notice in writing when the system is ready for final acceptance testing.

E. All measurements shall be made on the job site. Manufacturer published specification data or curves and measurements of typical models will in no case be considered as meeting this portion of the specifications.

F. 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 systems meets the Specifications and complies with applicable standards.

G. Report of tests and inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log upon the satisfactory completion of tests.

H. Train Owner's personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and maintaining of each system. Provide a minimum of 4 hours training.

I. Occupancy adjustments: When requested, any time within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

END OF SECTION 28 35 00

SECTION 28 46 19

SECURITY AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General provisions of the Contract, including General and Supplementary Conditions, and Division 28 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the hardware requirements for the Security Automation System and associated equipment. This shall include all hardware necessary to provide a complete and functional PLC-based GUI control system.

B. The SSI shall provide a new Security Automation System as specified herein. The system shall include all equipment, installation materials, set up, and testing to form a complete operating system. Independent system functions and integrated system functions to be fully verified as part of system testing and commissioning.

C. The SSI shall replace all existing PLC equipment with new equipment as specified herein. Existing door control and utility control enclosures shall be fully re-used. If existing enclosures are determined to be too small for the system requirements, the SSI shall provide new enclosures as required. All existing internal components including, but not limited to, sub-panels, wire duct, relay bases, relays, fuse holders, fuses, power supplies, power distribution, terminal strips, surge protection, etc. shall be replaced with new equipment as specified. All field cabling shall be labeled for easy identification.

D. All PLC input and output modules shall be distributed and interconnected utilizing an EtherNet/IP bus.

E. The SSI shall provide a PLC-controlled relay interface between the SSI-provided control relays and the branch circuits feeding lights and 120VAC receptacles. On/Off Control of these relays shall be from the GUI Stations. The SSI shall provide individual or group control of these circuits. Relays in series with “day” lighting circuits shall be wired normally closed. The “night” light circuits shall be wired to the normally open side of the relays. Relays in series with 120VAC receptacles shall be wired normally open. The SSI shall reference the Division 28 plans and specifications for relay control panel schedules and the Division 26 plans for panel board schedules.

F. The Security Automation System shall include the following main components:

1. PLC Equipment

2. Power Supplies

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3. Relays
4. Fuses
5. Door Release Pushbutton Station
6. Wall-Mount Duress Pushbutton Station
7. Under-Counter Duress Pushbutton Station
8. Under-Counter Door Release Pushbutton Station
9. Surge Protection Equipment
10. GUI Station Monitors
11. GUI Station PCs
12. Security Management Server & Monitor
13. Network Switches
14. Temperature Sensor
15. Uninterruptible Power Supplies
16. Loop Detector & Sensor

1.3 DEFINITIONS

A. GUI: Graphical User Interface

B. PLC: Programmable Logic Controller

C. NEC: National Electric Code

D. DVI: Digital Video Interface

E. VGA: Video Graphics Array

1.4 SUBMITTALS

A. Product Data: Include product specifications, operating characteristics, and accessories.

B. Shop Drawings: Detail equipment enclosure assemblies with dimensions, loads, required clearances, components, and locations.

1. Wiring Diagrams: Power, signal, and control wiring.

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C. Operation and Maintenance Data: Security Automation System shall be included in operation and maintenance manuals. Include the following:

1. Schedules detailing device names, termination locations, operating voltages, and fuse sizes of all equipment in the system.

1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

1.6 WARRANTY

A. Warranty Period: 12 months from date of Substantial Completion. The manufacturer shall repair or replace software and hardware that fails in materials or workmanship within specified warranty period.

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. Fuses: Furnish 10 spare fuses of each type provided.

2. Relays: Furnish 5 spare relays of each type provided.

3. PLC input module: Furnish 1 input module of each type provided.

4. PLC output module: Furnish 1 output module of each type provided.

5. PLC processor: Furnish 1 processor of each type provided, including a non-volatile memory card.

6. PLC power supply: Furnish 1 PLC power supply of each type provided.

7. Surge Protector: Furnish 1 spare surge protector of each type provided.

8. GUI Station PC: Furnish 1 spare GUI Station PC. The PC shall be loaded with the GUI software applications for all GUI station locations. Upon startup, the GUI shall prompt the installer as to what location the GUI is being installed.

PART 2 - PRODUCTS

2.1 PLC Equipment

A. Manufacturer:
1. Omron

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B. Description: The PLC system provides the logic control for the Security Automation System. The programmable controller shall interface to the GUI control stations. The PLC executes system commands and operations initiated by the GUI stations. The SSI shall be responsible for all PLC programming and security system integration. All security system related inputs and outputs shall be connected to the PLC I/O network. Hardwired device indication and control relays shall not acceptable.

C. System shall include a complete IEEE 802.3 100/1000 BASE-T Local Area Network that interfaces the GUI control stations, PLCs, Audio Communications Control equipment and the Digital Video Management System. Network shall be a closed network. Reference section 282300 for network switch requirements.

D. Provide a PLC system that is the product of a single company, which has regularly manufactured PLC equipment for a period of 15 years. Provide components that are regularly used in industrial automation applications. PLC racks and modules shall be DIN rail mountable. The control architecture shall use distributed control over Ethernet. Each controller shall share selected memory with all other controllers via broadcast messages over Ethernet.

E. PLC Processor
1. The PLC processor shall be an industrial rated controller capable of executing a basic cycle of instructions in less than 100 milliseconds.
2. The processor shall be capable of supporting 50,000 steps of programming and 160,000 words of data memory.
3. The processor shall utilize input and output modules of the same manufacturer to connect to security devices in distributed security equipment enclosures.
4. The processor shall have an embedded Ethernet port for communication to the GUI control stations.
5. The SSI shall provide a non-volatile memory card for each PLC processor provided.
6. The SSI shall configure the PLC to allow for programming using a connection to the facility's security network.
7. For systems with multiple PLC processors, failure of any PLC or PLCs shall not impact the operation of those remaining operational except to the extent that remote indications from the failed PLC may be lost.

F. PLC Input and Output Modules
1. I/O modules shall be distributed and interconnected utilizing an EtherNet/IP bus.
2. The I/O modules shall have LED indicators that reflect the state of each input or output point.
3. The I/O modules shall be capable of being replaced without the need to unwire field connections. All field wiring shall remain intact on removable connectors.
4. At each location that I/O is installed, provide a minimum of 10% spare input points and 10% spare output points.
5. Upon loss of power, faults, or communication failures with PLC I/O modules, all electric locks shall fail-secure. Sliding and overhead doors shall remain in their present state.

G. Security Interface
1. Owner shall provide a high-speed internet connection for use by SSI.

H. PLC Software
1. SSI shall provide the Owner with a licensed copy of the latest version of the PLC programming software. All necessary software to program and configure the PLC system

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shall be included with the software package. This software shall be installed on the Security Management Server. System program files and documentation shall be included with the programming software.

2.2 POWER SUPPLIES

A. Manufacturers:
1. Mean Well
2. Omron
3. PULS

B. Description: Din-rail mountable power supplies for powering the PLC equipment, electric locks and other related security devices. The basis for the specification is Mean Well.

C. 24VDC Power Supply
1. Rated for 120VAC input and 240W output
2. Short Circuit/Over-load/Over-voltage/Over-temperature protection with self-correction after fault is removed
3. Din Rail Mountable
4. UL508 (industrial control equipment) approved
5. LED indication for power on

2.3 RELAYS

A. Manufacturers
1. Omron
2. Eaton

B. Description: Relays shall be connected to the discrete outputs from the PLC and connect to field devices for signaling and control.

C. Door Control Relay
1. Coil rating of 24VDC @ 21mA
2. Contact rating of 250VAC @ 5A
3. Power consumption of no more than 0.5W
4. Slim socket design to allow for quick replacement.
5. LED for indication

D. Offender Telecommunication Circuit Control Relay
1. Coil rating of 24VDC @ 21mA
2. Contact rating of 250VAC @ 5A
3. Power consumption of no more than 0.5W
4. Slim socket design to allow for quick replacement.
5. LED for indication
6. Double-pole, double-throw

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E. Lighting/Power Circuit Control Relay: Provide SPDT relays per the application requirements. Reference Division 26 panel schedules and coordinate with the Division 26 contractor for exact requirements. The relays shall include the following features:
   1. Contact material: Silver Alloy
   2. Current rating: 20A
   3. Maximum Switching Voltage: 300V
   4. Electrical Life: 100,000 operations @ rated current (resistive)
   5. Switching Current @ Voltage (Resistive): 20A @ 277V 50/60Hz
   6. Switching Current @ Voltage (HP): 1 @ 277V
   7. SPDT

2.4 FUSES

A. Manufacturers
   1. ABB
   2. Sprecher + Schuh

B. Description: To ensure system integrity, all primary and secondary circuits shall be fused according NEC guidelines. A fuse shall be provided for each door control relay. Each fuse shall be uniquely labeled with an identifier. Each equipment cabinet containing fuses shall contain a "Fuse Schedule" sheet posted inside the door listing all fuses by the appropriate identifier and specify the operating voltage and fuse size for each

C. 24VDC FUSE HOLDER
   1. 5mm Din rail mounted fuse holder with screw clamps
   2. Rated for 250V @ 10A
   3. Shall be UL recognized
   4. LED indication

D. 120VAC FUSE HOLDER
   1. 17.5mm Din Rail mounted with screw clamps
   2. Rated for 600V @ 30A
   3. Shall be UL recognized

2.5 DOOR RELEASE PUSHBUTTON STATION

A. Manufacturers:
   1. Quam
   2. Harding Instruments

B. Description: The Door Release pushbutton stations shall consist of wall-mounted detention grade stainless steel wall plates containing crushproof pushbuttons where shown on the Security Drawings.

C. Door Release Pushbutton Station
   1. Single-gang, vandal-resistant 12GA brushed stainless steel faceplate
   2. Momentary, normally open, pushbutton.
   3. Mounted using #6-32 security screws
   4. Laser engrave the text "DOOR RELEASE" into the faceplate

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2.6 WALL-MOUNT DURESS PUSHBUTTON STATION

A. Manufacturers:
   1. Sprecher + Schuh
   2. GE

B. Description: The wall-mounted Duress Pushbuttons shall consist of a red illuminated mushroom-head pushbutton mounted to a detention grade stainless steel wall plate.

C. Wall-Mount Duress Pushbutton Station
   1. 30mm illuminated mushroom-head button with push-pull operation.
   2. Normally-closed, screw clamp, contact blocks
   3. Illumination via LED not incandescent bulbs
   4. Single-gang, vandal-resistant 12GA brushed stainless steel faceplate
   5. Engrave the text “DURESS” into the faceplate.

2.7 UNDER-COUNTER DURESS PUSHBUTTON STATION

A. Manufacturers:
   1. Potter
   2. Ademco
   3. GE

B. Description: Under counter pushbutton shall function as a duress signaling device to the Security Automation System. These devices shall be mounted under millwork out of public view so that they can be activated inconspicuously. The basis for the specification is Potter.

C. Under-Counter Duress Pushbutton Station
   1. Dimensions no greater than 2”W x 2 5/16”L x 1”H
   2. Can use maintained contacts (latching) or momentary contacts.
   3. Equipped with both Normally Open and Normally Closed contacts.
   4. Switch rating of 3A at 28VDC

2.8 UNDER-COUNTER DOOR RELEASE PUSHBUTTON STATION

A. Manufacturers:
   1. Alarm Controls (ASSA ABLOY)
   2. Potter
   3. GE

B. Description: Under counter Door Release pushbuttons shall provide a means of unlocking an electrically controlled door from a desk or countertop. The basis for the specification is Alarm Controls.

C. Under-Counter Door Release Pushbutton Station
   1. Dimensions no greater than 1-1/2”W x 2”L x 1”H
   2. Equipped with both Normally Open and Normally Closed contacts.
   3. Configured for momentary pushbutton operation
   4. Switch rating of 4A at 28VDC

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2.9 SURGE PROTECTION EQUIPMENT

A. Manufacturers:
   1. Transtector Systems
   2. Emerson Network Power
   3. Ditek

B. Description: Surge Protectors shall provide high speed transient protection for all security system power circuits as well as signaling and communication circuits for devices located exterior to the building. The basis for the specifications is Transtector Systems and Ditek.

C. 120VAC Surge Protection (Din-Rail Mount)
   1. Ditek model DTK-DR120P1
   2. The 120VAC surge protector shall include the following features:
      a. Surge Current Rating: 75,000 Amps
      b. SCCR: 200,000A RMS
      c. Frequency: 50-60Hz
      d. Connection Method: #14-4AWG Solid/Stranded Cu, Dry Contact: #30-16AWG
      e. Housing: IP20, UL94 V0
      f. Mounting: Din Rail – 35mm
      g. Surge Protection Status: Green – Normal, Red – Replace
      h. Remote Monitoring: Form C Dry Contact 250VAC/1A Max, 125VAC/3A Max
      i. Operating Temperature: -40°F - 185°F (-40°C - 85°C)
      j. Humidity: 5-95% Relative
      k. Dimensions: 4.19”L x 0.69”W x 2.81”H (1 Pole)

D. PoE RJ-45 Surge Protector
   1. Ditek model DTK-MRJPOE
   2. Ditek model DTK-RM12NETS
   3. Surge protector shall be used for each PoE camera located on the exterior of the building. Surge protectors shall be located in the security equipment head-end rack location(s).
   4. The PoE surge protector shall include the following features:
      a. Service Voltage: <60V
      b. Protection Modes: L-G (All), L-L (All)
      c. Clamping Voltage Common Mode: 75V
      d. Clamping Voltage Differential Mode: 7.22V
      e. Surge Current Rating: 20kA/Pair
      f. Power Handling: 144 Watts
      g. Data Rate: Up to 10GbE
      h. Connection Method: RJ45 In/Out or Shielded RJ45 In/Out, 12 Channels
      i. Housing: ABS or Galvanneal
      j. Operating Temperature: -40°F to 158°F (-40°C to 70°C)
      k. Maximum Humidity: 95% non-condensing

E. Intercom/Card Reader Surge Protection
   1. Ditek model DTK-2LVLPLV
   2. Surge protector shall be used for each intercom station or card reader mounted exterior of the building.
   3. The intercom/card reader surge protector shall include the following features:
      a. Protection Modes: Line-Ground (All)

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b. Surge Current Rating: 2,000 Amps per pair (5V –48V), 9,000 Amps per pair (75V –130V)
c. Max. Continuous Current: 5 Amps, 0.15 Amps (SCP)
d. Connection Method: Screw Terminals, #22-#16AWG
e. Housing: ABS
f. Operating Temperature: -40°F to 158°F (-40°C to 70°C)
g. Maximum Humidity: 95% non-condensing

2.10 GUI STATION MONITORS

A. Manufacturers:
1. Dell
2. Samsung

B. Description: Each GUI Station PC shall include one monitor. Provide 24” or 32” monitors as indicated on the plans.

C. 24” LED Monitor - The 24” monitors shall have the following features:
1. Diagonal Size: 24” diagonal, active matrix TFT LCD (LED)
2. Aspect Ratio: 16:9
3. Resolution: 1920 x 1080 @ 60Hz
4. Number of Colors: 16.7 million
5. Contrast Ratio: 1000:1
6. Input Video Format: VGA, HDMI, DisplayPort
7. Provide Dell Model P2419H or equal by Samsung

D. 32” LED Monitor - The 32” monitors shall have the following features:
1. Diagonal Size: 31.5” diagonal, active matrix TFT LCD (LED)
2. Aspect Ratio: 16:9
3. Resolution: 1920 x 1080 @ 60Hz
4. Number of Colors: 16.7 million
5. Input Video Format: HDMI x 2, Component x 1
6. Speakers: 2 x 10W
7. Provide Samsung Model UN32H5203 or equal by Dell

2.11 GUI STATION PC

A. Manufacturers:
1. OnLogic
2. Teguar
3. Industrial PC
4. No other manufacturers shall be considered

B. Description: Industrial Fanless Computer utilizing the HMI software to communicate with the PLC to control and monitor security system functions. The basis for the specification is OnLogic. This computer shall meet the following minimum specifications:
1. Processor: Intel Core™ i7-8650U (1.9GHz Quad Core Processor)
2. OS: Windows 10 Professional, 64-bit
3. Memory: 16GB SO-DIMM DDR4

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4. Hard Drive: 128GB M.2 SSD
5. Wireless Keyboard & Mouse: Logitech Model MK540
6. Provide OnLogic Model ML100G-31, or approved equal

2.12 SECURITY MANAGEMENT SERVER & MONITOR

A. Manufacturers:
   1. Dell
   2. HP

B. Description: The Security Management Server shall record all events that take place within the Electronic Security automation system PLC and GUI. The basis for the specification is Dell. Reference section 284620 for software requirements. The Server shall meet the following minimum specifications:
   1. Processor: Intel® Xeon® E-2234 3.60 GHz, 8M Cache, Turbo, 4C/8T
   2. OS: Windows Server 2019 Standard
   3. SQL Server 2019 Standard Edition
   4. Memory: 16GB
   5. Network Adapter: Dual GB NIC
   6. OS Hard Drive: 480GB SSD SATA
   7. Database Hard Drive: 960GB SSD SATA
   8. Removable Media: DVD-RW drive
   9. Integrated display video adaptor
   10. Dell basic keyboard
   11. Dell 2-button optical USB mouse
   12. Dell 22” LCD monitor, model E2216HV
   13. Lexmark Laser printer, model MS331dn

2.13 NETWORK SWITCHES

A. Manufacturers:

   1. Cisco
   2. HP
   3. Alcatel-Lucent

B. Description: The SSI shall provide the quantity of 24-port Layer 2 PoE switches to support all network devices on the security network. Switches shall support PLC hardware, GUI stations, audio communication equipment, security management system and other devices on the security network. Stacking cables shall be installed to connect similar switches at the same location(s). SSI shall provide and install the required quantity of 1GbE SFP optical transceivers at switch locations as required.

C. 24-port Layer 2 PoE Switches:

   1. The Layer 2 PoE switches shall include the following features:

      a. RJ-45 10/100/1000 Ports: 24
      b. Switch capacity with 4xGb/s uplinks: 56 Gb/s

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c. Switch frame rate with 4xGb/s uplinks: 41.66 Mp/s
d. Gigabit SFP ports: 4
e. Gigabit/5Gb/s Stacking Ports: 2/2
f. PoE Ports: 24
g. Dimensions (WxDxH): 17.32” x 9.92” x 1.73”
h. Weight: 11 lbs. (5.05 kg)
i. Operating Temperature: (Min) 32°F – (Max) 113°F [(Min) 0°C – (Max) 45°C]
j. Operating Humidity: 5 – 95% Non-condensing
k. Power Supply Nominal Input Voltage: 90-220VAC
l. Power Supply Output Voltage: 12VDC/54VDC
m. Power Supply Wattage: 525W
n. Power Supply PoE power budget: 380W
o. PoE device heat dissipation (BTU): 1296
p. Power Supply efficiency: 85%

2.14 TEMPERATURE SENSOR

A. Manufacturers:

1. Johnson Controls/Penn
2. Omega
3. West Control Solutions

B. Description: The SSI shall provide one or more (as required) temperature sensors to monitor the room temperature for the security electronics system head-end equipment racks located in rooms D108 and A114. The SSI shall set the low/high temperature thresholds of the sensor(s) in accordance with the temperature ratings of the installed equipment. Upon a low/high temperature alarm, the sensor(s) shall provide an output signal to the PLC system and they shall be annunciated on the GUI station(s). The basis for the specification is Johnson Controls.

C. Temperature Sensor:

1. The temperature sensor shall include the following features:

a. Power Consumption: 1.8VA maximum
b. Supply Power: 24VAC (20 to 30 VAC), 50/60 Hz, Class 2 or Safety Extra-Low Voltage
c. Ambient Conditions: -40 to 150°F (-40 to 66°C), 0 to 95% RH Noncondensing
d. Temperature Control Range: -40 to 212° (-40 to 100°C)
e. Input Signal: 1,035 ohm at 77°F (25°C) for A99 PTC temperature sensors
f. Sensor Offset Range: ±5°F or ±3°C
g. Output Relay Contacts Electrical Ratings: 100VA, 30VAC maximum, Class 2
h. Enclosure Material: Type 1/IP20 high-impact thermoplastic or Type 4X/IP66 watertight, corrosion-resistant, high-impact thermoplastic.
i. Provide Penn Model A421GBF-02C, or approved equal.

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2.15 UNINTERRUPTIBLE POWER SUPPLIES

A. Manufacturers:
1. Liebert
2. APC

B. Description: Uninterruptible Power Supplies (UPSs) shall be provided to provide battery backup protection for critical electronic security system hardware. The SSI shall provide 1500VA line interactive UPS units for Rooms C124, D200 and 089/C129. The SSI shall provide on-line units for Rooms 089/C126 (SQE#12), 089D/C129 (SQE#3), A114 (SQE#10), 056/B107 (SQE#8) and D108 (SQE#11). The basis for the specification is Liebert.

C. 1500VA Line Interactive UPS
1. Type: Line-interactive
2. Power Rating: 1500VA, or 900W
3. Nominal Input Voltage: 120VAC
4. Input Frequency: 50 or 60 Hz, +/- 5Hz, autosensing
5. Output nominal voltage: 120VAC
6. Receptacles: Five NEMA-15R
7. Provide Liebert model PSA5-1500MT120

D. 1.5kVA On-line UPS

1. Power Rating: 1500VA, or 1350W
2. Input Voltage Range: 120VAC nominal; variable based on output load
3. Input Frequency: 50/60Hz
4. Input Frequency Range: 40-70Hz, auto-sensing
5. UPS Technology: On-line
6. Receptacles: 5-15Rx6
7. Provide rack mounting kit for mounting in 19” rack
8. Runtime: Provide 15 minutes of runtime
9. Approved manufacturer: Liebert model GXT5-1500LVRT2UXL, or equal by APC

E. 5.0kVA On-line UPS

1. Power Rating: 5kVA, or 4.5kW
2. Input Voltage Range: 208V/120V 4-wire (L-L-N-G)
3. Input Frequency Range: 40-70Hz, auto-sensing
4. UPS Technology: On-line
5. Runtime: Provide 15 minutes of runtime
6. Provide wall-mount maintenance bypass switch
7. Approved manufacturer: Liebert model AS5A0NCVGNNXAZ3, or equal by APC

2.16 LOOP DETECTOR AND SENSOR

A. Manufacturer:
1. EMX Industries, Inc.

B. Description: Two vehicle Loop Sensors shall be located at the entrance to the vehicle sallyport. Each sensor shall be connected to a separate Loop Detector, located inside of the vehicle

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sallyport. Upon activation of the sensor by a vehicle, the loop detector shall provide indication to the PLC system for annunciation on the Central Control GUI station. The basis for the specifications is EMX Industries.

C. Loop Detector
1. EMX Model Carsense CS303-C-1
2. The Loop Detector shall include the following features:
   a. Sensing Technology: 3-axis magnetoresistive
   b. Axis sensitivity: 512 counts/gauss (typical)
   c. Environmental tracking: Automatic compensation
   d. Local magnetic field nulling: Averages local field signature in any sensor orientation
   e. Detection range: 5 ft. (1.5m)
   f. Power/fault indicator: Green LED
   g. Detect indicator: Red LED
   h. Pulse/presence: Allows the relay/NPN output to send either a pulse output or have constant presence
   i. Detect-On-Stop: Requires vehicle to stop for a minimum of 1 second (1-2s typical)
   j. Outputs: SPDT relay/NPN (open collector)
   k. Output ratings: Relay: 1A @ 24VDC…120VAC NPN: 50 mA (max)
   l. Connection: 10-position screw terminal
   m. Operating environmental: -40°C…82° C (-40°F…180°F) and 0…95% relative humidity
   n. Housing: ABS
   o. Environmental rating: IP30
   p. Power supply: 12-30VDC and 24VAC
   q. Current draw: 40mA max
   r. Supply protection circuitry: Reverse polarity and fuse protected
   s. Dimensions: 76mm x 22mm x 70mm
   t. Weight: 68g

D. Loop Sensor
1. EMX Model CS303-DB-100
2. The Loop Sensor shall include the following features:
   a. Connection: 5-conductor direct burial
   b. Housing: Polyamide
   c. Environmental rating: IP69K
   d. Power Supply: 12-30VDC
   e. Current draw: 10mA max
   f. Dimensions: 102mm (4.0”) x 27mm (1.0”)
   g. Weight: 43g

2.17 INSTALLATION

A. Provide complete Security Automation System as specified herein.

B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

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C. All system equipment to be contained within equipment racks and cabinets. If more or larger equipment racks or cabinets are required than exist or are specified, allow for such additional equipment racks and cabinets in contract price.

D. Provide adequate ventilation for all heat radiating equipment. SSI shall provide fan kits as required to maintain rated operating temperature of installed equipment.

E. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

F. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

G. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

2.18 CONNECTIONS

A. Ground equipment according to manufacturer’s recommendations.

2.19 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: A trained service representative to inspect, test, and adjust PLC system components and equipment installation, including connections, and to assist in field testing.

B. Perform the following field tests and inspections and prepare pass/fail reports:

1. Field Device Test: SSI shall perform an inspection of each field device connected to the PLC system to ensure that each is properly working, installed, and configured for its particular location.
2. The SSI shall also verify that all PLC events are being logged to the Security Management Server

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

2.20 DEMONSTRATION

A. A trained service representative will perform system maintenance training at the Owner’s facility once the final inspection is complete.

B. Training shall be video recorded.

END OF SECTION 28 46 19

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SECTION 28 46 20

VIDEO GRAPHIC USER INTERFACE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General provisions of the Contract, including General and Supplementary Conditions, and Division 28 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This project includes replacing two existing graphical user interface (GUI) stations in Dispatch & Turnkey/Control Room 089/C126 with new stations and providing one new GUI station in Control Room D200.

B. This Section includes the requirements for the video graphic user interface (GUI). The GUI software shall be the primary interface to the PLC and Electronic Security System. The GUI software operating on the GUI Station PCs shall communicate to the PLC processors for security systems operation.

C. The GUI software shall be programmed and configured to provide all functionality as described in this specification section. The GUI software shall communicate with all required security system components to display, control and monitor all security devices as specified and shown on the plans.

D. GUI stations shall be provided as shown on the plans. The GUI stations in Dispatch/Control Room 089/C126 and Control Room D200 shall be considered “Master GUI stations” and shall have the ability to take over all functions and disable/enable each other through passcodes.

E. The video graphic user interface shall include the following main components:

1. HMI Development Software
2. Door Control
3. Video Monitoring
4. Intercom Communication
5. Utility Control
6. Duress Alarms
7. Emergency Features
8. Additional GUI Features

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9. Security Management Server Software

1.3 DEFINITIONS

A. GUI: Graphical User Interface

B. PLC: Programmable Logic Controller

C. HMI: Human Machine Interface

1.4 SUBMITTALS

A. Product Data: Include software datasheets, operating characteristics, and accessories required.

1. Shop Drawings: Provide all Graphical User Interface layouts. Layouts shall be created by the GUI configuration software and shall not consist of line drawings created by CAD programs. The Owner reserves the right to request the Division 28 SSI to make changes (during the submittal process) to the GUI layouts based on the Owner's policies and procedures, without incurring any additional cost to the Owner.

B. Operation and Maintenance Data: Include the following:

1. Detailed operations manual describing all features of the GUI including all administrative features.

2. Schedules detailing IP address, model numbers, locations, titles, and termination locations of all GUI stations in the system.

1.5 QUALITY ASSURANCE

A. All GUI development shall be done by a Certified Partner of the HMI manufacturer and adhere to all recommended development standards.

1.6 WARRANTY

A. The SSI shall warranty the GUI software to be free of defects for a period of 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 HMI Development Software

A. Manufacturer:
1. InduSoft (Aveva™)
2. Aveva™ InTouch HMI

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B. Description: The GUI application(s) shall be developed using a non-proprietary industrial development suite designed for real-time connections to PLCs and other types of remote I/O devices. The development environment shall allow for the creation of animated operator interface screens utilizing an application tag database.

C. HMI Development Software
1. The HMI shall support the number of I/O tags as required for each application in the system.
2. The HMI shall allow for sophisticated scripting for customizing applications for specific needs.
3. The HMI shall allow for Microsoft ActiveX controls and .NET controls integration.
4. The HMI shall allow for resolution independent graphics and intelligent symbols.
5. The HMI shall allow for template-based development of objects and graphics.

D. HMI Screen Development
1. Provide screens utilizing accurately depicted, properly aligned floor plans. Floor plans shall be displayed as seen from the GUI control station operator's perspective.
2. Provide screens that incorporate the use of screen resolution and color to enhance and simplify the information displayed. Provide a light gray background for all screens. Provide screens that utilize contrasting colors. GUI screens shall use red for alarm conditions, yellow for cautionary conditions and information such as the depiction of interlock groups, use green for audio communication functions and blue for video surveillance.
3. Provide the number of screens that support the sequences of operation as required by the system.

2.2 DOOR CONTROL

A. DOOR ICON – The Door Icon shall activate a door menu which appears next to the selected door icon and contains all functions available for that particular door. Possible functions include: UNLOCK, HOLD OPEN, CLOSE, INTERLOCK OVERRIDE, ISOLATE, and ALARM CLEAR. While the door is selected, a BLUE (flashing) selection ring shall surround the door icon showing the operator which door is under their control. Only after the door has been selected can any other function be selected. This two-keystroke operation for unlocking is important so that doors cannot be accidently unlocked. The same control methods are required for swing, sliding, and overhead doors. When the operator selects a door menu function the GUI shall audibly announce which function was selected. To unlock a door, the operator must first select the door, then from the door menu select the "UNLOCK" function. The GUI will then announce "Unlock", if the door was a swing door then the door will be unlocked for 3 seconds and then automatically relock. If the door was a sliding door or an overhead it will open fully and stop. To stop the opening or closing of a sliding or overhead door the operator can press the "STOP" button which will stop the motion of the traveling door. To hold a swing door open or unlocked, the operator shall first select the door and from the door menu select "HOLD-OPEN". The door will remain in the unlocked position until the operator selects the door and presses the "CLOSE" button. To close a sliding or overhead door, the operator shall first select the door and from the door menu select the "CLOSE" button. The selected door will then close completely. If a door is selected but no menu function is pressed the door menu will time-out after 5 seconds and disappear.

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1. DOOR MENU - When a Door Icon is selected a menu shall appear next to the icon and contain all functions available for that door. Such functions shall include UNLOCK, HOLD OPEN, CLOSE, INTERLOCK OVERRIDE, ISOLATE, and ALARM CLEAR. If no selection is made within 5 seconds the door menu shall timeout and disappear.

2. DOOR INDICATION - The Door Icon shall include a symbolic representation the status of the door. The door symbol should represent the door and its current state (i.e. opened, closed, unlocked, etc). Swing door icons shall look like swing doors opening and closing during operation, sliding doors shall appear to slide open and closed during operation, and overhead door icons shall look like overhead doors opening and closing during operation. The Door Icon shall have the following states:
   a. The door icon button is gray and the door symbol is gray when the door is locked and secured.
   b. The door icon button is red and the door symbol is gray when the door is powered but the lock status switch and the door position switch are still indicating that the door is secure.
   c. The door icon button is red and the door symbol is red when the door is powered and unsecure.
   d. The door icon button is gray and the door symbol is red when the door is not powered but is unsecure.
   e. The door icon button flashes red and the door symbol shows the current status of the door if the door is violated. A door shall be considered ‘violated’ if it is opened by any other means than the Security Automation System. The GUI shall annunciate “DOOR VIOLATION” until the alarm is acknowledged.
   f. Interlocked doors shown with yellow outlines around their buttons when a door in an interlock group is unsecure. If an interlocked door is attempted to be unlocked, the GUI shall annunciate "Not allowed, door is interlocked."

3. DOOR GROUPS - Doors can also be configured into groups. The Door Groups shall be controlled using the “GROUP” button located within the GUI. To control a group of doors the operator shall first select the appropriate “GROUP” icon which displays the Group Menu. From the menu the operator can select to “UNLOCK”, “HOLD OPEN”, or “CLOSE” all doors in that group.

4. DOOR ISOLATE - Electrically controlled doors can be isolated such that they cannot be opened from the GUI or from other field devices such as pushbuttons, proximity readers, or motion detectors. To isolate a door, the operator first selects the door which displays the door menu. From the menu, the operator selects “ISOLATE” which places a large red “X” on the door icon. Once isolated, all door unlocking functions will not be available. This feature is also used to isolate doors from being unlocked using the Group Unlock function. The door remains isolated until the operator selects the door and presses the “ISOLATE” button again which removes the large red “X” from the door icon.

5. INTERLOCKS - Interlock groups as defined by the Owner shall be configured as a function of the Security Automation System. These interlock groups are to be programmed into the PLC and not be hardwired or mechanical and are intended to allow only one door in a group to be unlocked at any one time.
   a. When a door in an interlock group becomes unlocked or unsecured all doors in that group including the unsecure door will be shown with a yellow outline around the

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icon. This denotes an “active interlock”.

b. If the operator tries to unlock a door in an active interlock the GUI shall audibly tell the user “Denied, Door is Interlocked”.

c. Active interlocks shall be displayed on all GUI stations regardless of whether they are in primary control of that area.

d. To unlock a door within an active interlock group, the operator must use a minimum of two steps to unlock a door.

1. First select “Interlock Override” from the Door Menu. The GUI shall audibly warn the operator of the risks involved in the action.
2. The operator must then select “CONTINUE” to override the interlock. The system shall allow the user to unlock one door in the interlock group then reactivate the active interlock group

e. When all doors in an interlock group are secured the yellow outlines shall disappear.

6. EXTERIOR DOOR CONFIRMATION - The GUI software shall be configured to require a second confirmation step before unlocking exterior doors. After the operator attempts to perform the Unlock command a window shall appear asking the operator to acknowledge the security risk in unlocking an exterior door. The operator must press the YES – UNLOCK button before the system will unlock the door. The other option is to press the NO – ABORT button, which will cancel the function.

2.3 VIDEO MONITORING

A. Video monitoring from the GUI is accomplished by selecting any VIDEO CAMERA ICON. Each Video Camera Icon represents a camera within the system. The orientation of the camera symbol shall be representative of the actual direction of the camera. Once selected, the icon will turn from gray to blue and the video image of the camera will be displayed live within an onscreen video display window. Two onscreen video display windows shall be incorporated into the GUI. One window shall be used for manual camera call-up and the other window shall be used for intercom follow. Selecting another camera icon shall cause its camera to become active and cancel the previous camera. When cancelled, the camera icon shall change from blue, back to gray. To populate a video display window with a selected camera image, the operator shall right-click on the selected VIDEO CAMERA ICON and a pop-up menu shall display a graphical view of the available video display windows. The operator shall then be able to select the desired video display window to populate with the selected camera. For the two video windows dedicated to manual camera call-up and intercom follow, pressing any Video Camera Icons (or an active intercom follow) will override any camera being displayed.

2.4 INTERCOM COMMUNICATION

A. Establishing Intercom audio communications from the GUI is accomplished by selecting any INTERCOM ICON. These icons shall be placed on the floor plan at the location of each intercom station. Selecting the icon will immediately activate the intercom station and allow the control station to monitor the audio at the station. The Intercom icon will turn from gray to green upon activation and the station ID# is displayed in the “IN USE” field of the GUI. Pressing the “Push-To-Talk” button located at the GUI station shall allow the operator to communicate with the intercom station. Pressing the active Intercom icon again will cancel the connection. Pressing another Intercom icon will automatically connect the operator to that station and cancel the previous connection. If there is a camera in view of the intercom station it shall be automatically connected to the video display window (reference 2.3, A). When connected the Video Camera Icon camera

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symbol shall display a green indicator showing that it has been called up following the intercom connection. The Intercom Icon shall have the following states:

1. If an intercom call button, located on or at the intercom station, is pressed the INTERCOM ICON flashes green and the GUI shall sound a call notification until the call is connected or the ACKNOWLEDGE button is pressed.
2. Once the call is answered, the INTERCOM ICON shall turn solid green. If another call is incoming while the first is being serviced, that INTERCOM ICON shall flash but the GUI shall wait to annunciate the call notification until the current active intercom is disconnected.

B. ISOLATE INTERCOM – This feature allows the operator to remove the intercom stations ability to audibly call the GUI station. To isolate a station, the operator must first press the "ISOLATE INTERCOM" button then select which station(s) to isolate. The first time the icon is pressed a large red "X" is placed on the Intercom icon denoting it as isolated. The GUI software shall allow the user 3 seconds to select other stations before timing out. To remove the isolation the user shall repeat the process which will remove the large red "X" from the icon.

C. AUDIO LEVEL MONITORING: This feature shall monitor the audio levels in predetermined areas and provide notification when the audio level exceeds the present setting. When the level is exceeded the intercom shall sound the call notification, flash the intercom icon, and display the text "ALARM" in red letters on the intercom icon.

D. INTERCOM AUDIO WINDOW – There shall be an Intercom Audio window integrated into the control menu for displaying the status of the intercom audio system. A portion of this window shall indicate which intercom station is currently active. In addition, there shall be a pending list displaying the 6 oldest intercoms in the queue. To answer a pending intercom the operator can either select the flashing intercom icon or select it out of the queue. Selecting the intercom out of the queue connects the operator to that station and its station ID# shall appear in the "In Use" field of the intercom audio window. Furthermore, when the station is selected out of the queue the GUI shall automatically switch the operator to the screen that contains the active intercom. To disconnect, the operator can simply press the station ID text in the "In Use" field or press the active intercom icon.

2.5 UTILITY & MISC. CONTROL

A. Utility control is a menu function that once selected displays all Light Icons, TV Receptacle Icons and Inmate Telephone control Icons. The GUI software shall give the operator 5 seconds to select an icon before it is hidden. During this time period, all Intercom Icons and Paging Icons shall be hidden in the background. Once an icon is selected, the timer shall start over and allow 5 more seconds before hiding the icons. Selecting a Utility Icon while the function is active shall cause the utility to turn "ON" if it is "OFF" and "OFF" if it is turned "ON". Utilities groups can also be controlled using the "GROUP" button while the menu selection is still active and the icons are visible. Pressing the "GROUP" button once shall turn all utilities "ON" and pressing again shall turn them all "OFF".

B. During an emergency evacuation event or other emergency occurrence, all lights in the area of the event shall be configured to turn ON (if configured to be controlled via the PLC GUI system).

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C. PROXIMITY READER ICONS – Proximity Reader Icons shall be placed on the GUI screens where proximity readers are located. When a proximity reader has a valid credential read that provides access for the user, the Proximity Reader Icon shall turn green for 3 seconds. Proximity Readers shall be able to be isolated (or disabled). When the icon is pressed a large yellow "X" is placed on the Proximity Reader icon denoting it as isolated. To remove the isolation the user shall repeat the process which will remove the large yellow "X" from the icon.

2.6 DURESS ALARMS

A. DURESS ALARM ICONS shall be placed on the GUI screens that represent the physical locations of actual duress pushbuttons stations around the facility. Duress Alarm Icons shall normally be hidden when not active. When a duress alarm pushbutton station is pressed the Duress Alarm Icon shall be displayed and shall flash. The GUI shall annunciate "OFFICER ALARM" until the alarm is acknowledged. Once the alarm is acknowledged, the icon shall continue to flash with no audible alarm until the actual physical pushbutton station is reset by releasing the latched pushbutton. Once the pushbutton station is reset the icon shall be hidden in the background.

2.7 EMERGENCY FEATURES

A. EMERGENCY MENU: Located on GUI menu shall be a button labeled "EMERGENCY." Pressing this button will display the Emergency Menu which consists of various emergency related function buttons. These buttons shall include: RELEASE ALL, and LOCKDOWN.

1. RELEASE ALL button:
    a. When pressed, this button shall begin the Emergency Evacuation sequence and display a window explaining the risk of the action. The GUI shall also audibly warn the operator of the risks involved in continuing the action. On the step 1, window there shall be buttons to CONTINUE and ABORT.
    b. If the operator continues, the first window shall disappear and a second window shall again warn of the danger and risks involved in continuing. Also the GUI shall place "E" symbols on all controlled doors that will be released and again warn the operator of the dangers involved in continuing. On the step 2 window, there shall be buttons to CONTINUE and ABORT.
    c. If the operator chooses to continue, a full screen window shall appear stating that this is the final warning before release. An audible message shall warn the operator that after this step, all doors with "E" symbols will be released. On the step 3 window, there shall be a button to CONTINUE and the ABORT button should at least 10 times larger in size.
    d. Pressing continue will begin the unlocking sequence, all doors with "E" symbols will be released or opened.

2. LOCKDOWN button: The Emergency Window shall contain a LOCKDOWN button. This button shall lock all held-open swing doors as well as close all sliding and overhead doors. This feature shall also disable all access devices such as proximity readers and door release pushbuttons.

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2.8 ADDITIONAL GUI FEATURES

A. NAVIGATION PANE – There shall be a portion of the GUI screen dedicated to screen navigation for the Security Automation System. This shall be a graphical representation of the floor layout segmented to represent each screen. This area is also used to display Door Violation Indication, Alarm indication and Pending Intercom indication. When a door on particular screen violates the screen associated with that door flashes red indicating to the operator that their attention is required. Other devices that should be indicated by a red flash in the Navigation Pane include: Fire Alarm System Annunciation. Pending Intercom stations shall flash their respective windows green to help assist the operator in finding the pending station. The current active screen shall be displayed as white allowing the user to see their current location

B. ALARM ACKNOWLEDGE - Selecting this icon shall acknowledge and silence the audible notification used to indicate a violated door, intercom station call, or any other alarm.

C. CONTROL ROOM DURESS - Selecting this icon shall immediately DISABLE all functions of the GUI. This feature shall be included on GUI stations outside of Master Control.

D. ADMINISTRATIVE UTILITIES MENU - Located on the menu shall be a button for configuring convenience and maintenance options to the operator.

1. A ‘COMMAND FUNCTIONS’ button shall allow the operator to shut-down the GUI software applications. Upon selecting the button, the operator is prompted to provide an administrator-level password before the software applications are shut down.
2. A ‘VOICE STYLE’ selection shall allow the operator to select between a female, male, or basic for common GUI functions. For audible alarm indications, the GUI shall play a male or female voice always.
3. A ‘CALIBRATE SCREEN’ button shall allow the operator to calibrate the GUI overlay for proper touch alignment.
4. A ‘CLEAN SCREEN’ button shall allow the operator to clean the surface of the GUI display with a manufacturer approved cleaning product. The screen shall be “blanked” so that no icons or control functions are available to the operator. An onscreen message shall tell the user what types of cleaning products are approved.

2.9 SECURITY MANAGEMENT SERVER SOFTWARE

A. All events that take place within the PLC and Electronic Security System shall be logged to a Security Management Server provided by the SSI. The HMI software installed on the GUI stations shall not be dependent on the security management server and software. The loss of functionality of the security management server shall in no way affect the normal operation of the GUI software.

B. The security management server shall have the following features:

1. Record Device Events for the following field devices:
    a. Doors
    b. Intercoms
    c. Proximity Readers
    d. Cameras
    e. Utility Control (Lighting, TV Receptacle, Inmate Phone control)
    f. Misc. Alarms (Duress, etc.)
    g. Any other project-specific device

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2. Record Control Point events for each GUI station. These events shall be visibly different from Device Events and display which control point and which user initiated the event. A control point shall consist of events generated by a GUI station. Control Point events shall include the following events;
    a. Touchscreen Status
    b. Interlock Override
    c. Emergency Evacuation
3. The software shall allow the user to enter a credential, or 4-digit pin for each GUI station.
4. Event log shall be stored in a SQL database and be archived for retrieval.
5. The security management server shall provide the user the ability to display the previous 100, 50 or 25 events dynamically updating on the screen.
6. The security management server shall provide the user the ability to adjust the refresh rate for the events at a rate of 10 seconds, 30 seconds, 60 seconds or 5 minutes.
7. The user shall be able to filter the dynamic event display by device type.
8. The dynamic event display shall display columns for Control Point/User, Timestamp (the date and time of the event), Device Name, Event Type, Device Description/Note, Device Type, Area Name (location area name the specific device is grouped in).
9. The user shall be able to generate reports based on database queries for event names or time of occurrences. This report shall be displayed on screen and the user should be allowed to print the report.
10. Devices and their associated events shall have the ability to be grouped based on their respective locations in the building. (i.e. Cell Block A, B, C, Booking, etc.)
11. The user shall have the ability of performing a search function that looks for keywords such as type of event, area of the building, or device names. The search function will replace the dynamic event view with the returned list based on the search criteria. The user can either choose to see the previous 100 events (based on the search criteria) or all events containing the keyword(s) searched.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Perform and document the following pass/fail tests:
    1. Verify field operation of every icon and button relating to the Electronic Security System GUI.

3.2 ADJUSTING

A. SSI shall provide basic adjustments to text, color, and representation of the facility at no additional charge during the final inspection of the project.

3.3 DEMONSTRATION

A. A Certified Systems Developer will perform the training at the Owner’s facility once the final inspection is complete.

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B. Training shall be video recorded.

END OF SECTION 28 46 20

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SECTION 28 51 23

IP AUDIO COMMUNICATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 01, and Division 28 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the requirements for an IP audio communication system. The IP audio communication system shall be integrated with the overall Electronic Security System. The system shall be configured to support all intercom stations, speakers and touchscreen master modules shown on the security electronics plans.

B. All existing audio communication head-end equipment located at SQE#3 shall be removed and disposed of. This shall include all existing relay cards, power supplies, terminal strips and all other unnecessary equipment. The SSI shall provide new audio communication equipment as specified herein to support all existing intercom and speaker locations that are to remain. The SSI shall re-use the existing equipment enclosure for the new head-end equipment.

C. All existing intercom stations shall be replaced with new stations as indicated on the plans. The SSI shall replace all existing wall speakers with new as indicated on the plans.

D. The SSI shall provide an integrated IP audio communication system as specified herein. The system shall include all equipment, installation materials, set up, and testing to form a complete operating system. Independent system functions and integrated system functions to be fully verified as part of system testing and commissioning.

E. The Graphic User Interface (GUI) software (specified in section 284620) shall be the primary interface for the control and monitoring of the IP audio communication system (reference section 284620 for software functional requirements).

F. The SSI shall provide a digital interface between the PLC system and the Digital Communication Controllers for control by the PLC.

G. Digital Communication Controllers and Digital Communication Expanders shall be interconnected to form intercom exchanges. Each Digital Communication Controller (DCC) shall be capable of supporting up to four Digital Communication Expanders (DCEs). The SSI shall provide and install the required number of DCCs and DCEs to support the total number of intercom stations, ceiling speakers and touchscreen master modules in the system. All DCCs shall be connected to each other over a 10/100/1000Base-T network. This network shall provide data communications for the system. Reference section 282300 for network switch requirements.

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H. The system shall include station audio level alarm detection (for ceiling speakers requiring this feature, as indicated on the plans) with adjustable detection settings for each individual station. SSI shall include with their bid the head-end equipment required to support this feature. The SSI shall adjust the audio level alarm detection settings for each station, with input from the Owner.

I. The SSI shall provide an audio recording system to digitally record all the audio conversations between each audio master station and intercom stations, ceiling speakers, paging speakers and paging horns.

J. The SSI shall NOT provide PLC-controlled relay cards to control audio line switching at the security electronics head-end. All switching shall be provided by Harding digital communication controllers (DCCs) and digital communication expanders (DCEs).

K. The IP audio communication system shall include the following main components:

1. Digital Communication Controllers and Expanders
2. Administrator Software
3. Audio Master Stations
4. Intercom Stations & Loudspeakers
5. Accessories
6. Audio Recording System

1.3 DEFINITIONS

A. DCC: Digital Communication Controller

B. DCE: Digital Communication Expander

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: Detail equipment enclosure assemblies and indicate dimensions, loads, required clearances, components, and location of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For IP audio communication system to include in operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Schedules detailing locations, titles, and termination locations of all intercom stations, ceiling speakers and touchscreen master modules in the system.

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1.5 QUALITY ASSURANCE

A. All work shall conform to applicable National Electrical Codes (NEC). SSI shall adhere to applicable state and local ordinances and the requirements of the authority having jurisdiction.

B. Intercom system equipment is to be designed and manufactured in accordance with ISO-9001 2000 Quality System Standard.

C. Manufacturer's quality control program to be registered in accordance with the above noted standard.

1.6 WARRANTY

A. Warranty Period: 12 months from date of Substantial Completion. The manufacturer shall repair or replace software and hardware that fails in materials or workmanship within specified warranty period.

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. Intercom Station: Furnish 1 spare intercom station of each type provided.

2. Touchscreen Master Module: Furnish 1 spare touchscreen master module.

PART 2 - PRODUCTS

2.1 DIGITAL COMMUNICATION CONTROLLERS

A. Manufacturer:

1. Harding Instrument Co. Ltd. - MicroComm DXL

B. Description: SSI shall provide required number of Digital Communication Controllers to form an intercom exchange capable of independent local operation. Each exchange capacity shall be increased as required by connecting additional Digital Communication Expanders (maximum of 4) to each DCC. The basis for the specification is Harding Instruments.

C. Digital Communication Controller (DCC):

1. Each DCC shall include the following:

a. Process Control Card (PCC)
b. Master Control Card (MCC)
c. Two Station Control Cards (SCC's)
d. Optional internal PCI card.
e. Front panel keypad/display for system setup and maintenance.

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f. 110 VAC, 60 Hz power supply for internal functions.

D. Process Control Card (PCC):

1. Process Control Card shall contain system configuration and data, control exchange operations and switching, and provide exchange network ports.
2. PCC shall include the following:

a. USB network ports for exchange expansion.
b. Ethernet network ports for system expansion and external control by touch screen computers and graphic control panels.
c. Fiber optic or copper digital audio trunk ports.
d. Two serial ports.
e. Internal modem for transmitting and receiving data over a telephone line.

E. Master Control Card (MCC):

1. MCC shall include the following:

a. Include ports for any combination of two intercom or telephone set master stations.
b. Include two line-level audio inputs with status and control.
c. Include two line-level audio outputs with status and control.
d. Convert incoming audio signals to digital format and outgoing signals to analog format.
e. Intercom master station audio, press-to-talk and hook switch status transmitted over two single shielded pair cables with wiring supervision to detect open circuit and short circuit faults.
f. Telephone set master station functions all transmitted over a single wiring pair.

F. Station Control Card (SCC's):

1. SCC's shall include the following:

a. Each provides sixteen half-duplex intercom station ports which can be employed in adjacent pairs for full duplex devices.
b. Provide an interface for intercom stations. Units to convert incoming audio signals to digital format and outgoing signals to analog format. Each channel to monitor the status of up to two (2) switches associated with each intercom station.
c. Each card interfaces with 16 half-duplex channels. Each channel includes a separate audio power amplifier for non-blocking call operation and sixteen (16) independent software-controlled volume settings.
d. All station audio, switch, and power functions on 400 Series and 401 Series cards to be transmitted over a single shielded pair cable with supervision to detect open circuit and short circuit faults.
e. Audio and switch functions on 300 Series (Generic Intercom) station control cards to be transmitted on separate wiring pairs.

2.2 ADMINISTRATOR SOFTWARE

A. Manufacturer:

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1. Harding Instrument Co. Ltd. - MicroComm DXL

B. Description: Administrator software shall be included with the IP audio communication system. SSI shall provide one licensed copy of the administrator software to the Owner at final completion. The basis for the specification is Harding Instruments.

C. Administrator Software:

1. Harding Instruments model DXL-SOF-ADM.
2. Administrator Software to function on a standard PC to support system configuration, diagnostics, maintenance, and logging but not be required for system operation.
3. Administrator Software to employ Windows features including views of system tree structure, tables of devices, screens for system settings and adjustments, and tables of operational data.
4. Configuration features to include:

    a. Creation of overall system architecture.
    b. Creation of multiple device templates.
    c. Copy and paste functions with auto-numbering and auto-assignment to create device schedules.
    d. Configuration error detection and alerts.
    e. Device naming and call routing functions.
    f. Device setting and performance functions.

5. Diagnostic and Maintenance features to include:

    a. Verification of system configuration and installation.
    b. Verification of system networks.
    c. Verification of device connections.
    d. Verification of system operation.
    e. Diagnostics via modem or Ethernet ports.

6. Logging features to include:

    a. Display of system activity with filtering options.
    b. Search by time and date.
    c. Search by device.
    d. Search by parameter.

7. SSI shall install a licensed copy of the Administrator software on the Security Management Server.

2.3 AUDIO MASTER STATIONS

A. Manufacturer:

1. Harding Instrument Co. Ltd. - MicroComm DXL

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B. Description: VoIP Touchscreen Master Modules shall be provided to interface with the IP audio communication system. One VoIP touchscreen master module shall be provided at each GUI station location. The basis for the specification is Harding Instruments.

C. VoIP Touchscreen Master Module:

1. Harding Instruments model TMM-641-121-1.
2. The VoIP touchscreen master module shall include the following features:

a. Dimensions: 2.01” (H) x 5.35” (W) x 7.07” (D)
b. Operating Temperature: 32° to 122°F (0° to 50°C)
c. Humidity: 0 to 95% non-condensing
d. Field Connections: female RJ-45 connector
e. Power: 22.8Vdc – 37.8Vdc or EEE 802.3af compliant
f. Switch: 1 million operations
g. Speaker: 2.5” Mylar cone
h. Speaker level: 82 dB SPL max. @ 1 meter
i. Audio Output: 1V rms

D. Telephone Set Master Station (VoIP with PoE):

1. Harding Instruments model IMS-641-1.
2. The telephone set master station shall include the following features:

a. Dimensions: 8.5” (H) x 8” (W) x 2” (D)
b. Operating Temperature: 32° to 122°F (0° to 50°C)
c. Humidity: 0 to 95% non-condensing
d. Connections: Handset port; RJ9 connector, Headset port; RJ9 connector, LAN Ethernet port; RJ45 connector, Power connector; DC jack
e. Power Requirements: 30 to 58VDC, 36VDC wall adapter or Power-over-Ethernet

2.4 INTERCOM STATIONS & LOUDSPEAKERS

A. Manufacturers:

1. Harding Instrument Co. Ltd. - MicroComm DXL
2. Quam-Nichols Co. (for loudspeaker only)
3. Lowell (for loudspeaker only)

B. Description: Intercom stations and loudspeakers shall be provided as shown on the plans. Intercom stations shall be the primary means of communication in the IP audio communication system between the GUI operator and the facility staff and offenders. All intercom stations shall include a call pushbutton switch. Ceiling speakers shown on the plans as designated with a “T” shall include audio threshold detection. The basis for the specification is Harding Instruments.

C. Intercom Stations:

1. Harding Instruments model ICE-420-217-000 for interior locations.
2. Harding Instruments model ICE-420-227-000 for exterior locations.

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3. Harding Instruments model ICE-421-CUS-105 for interior locations with included “privacy switch” feature.
4. Harding Instruments model FDH-420-204-110 for interior stations with integrated handset.
5. Harding Instruments model ICE-620-227-000 for exterior site-located, pedestal-mounted IP stations.
6. The intercom stations shall include the following features:

    a. Intercom stations shall be designed for mounting on standard 2-gang outlet boxes. Faceplates shall be constructed of 11-gauge brushed stainless. Internal steel offset grille to restrict inserting objects through speaker grille. Stations shall be ruggedly constructed and resistant to damage from soil and sprays.
    b. Each intercom station shall incorporate an internal loudspeaker, microphone preamplifier and functioning multiplexing circuitry. One pushbutton shall be provided on each station. Pushbuttons shall be software assignable for placement of call requests or control of auxiliary functions.
    c. Pushbuttons shall be single piece stainless steel construction and shall be backstopped to prevent excessive travel. Switch shall have positive tactile action with 1 million-operation lifetime.
    d. Loudspeakers shall be waterproof Mylar cone type.
    e. Stations shall be provided with MTA type insulation displacement connector that requires no wire stripping for installation.
    f. Outdoor intercom stations shall be identical in all respects to standard intercom stations except that all metal plates and hardware shall be stainless steel, and internal circuitry and components shall be conformal coated.

D. Loudspeakers – Surface Mount:

1. Quam model SYSTEM 1VP, or equivalent by Lowell
2. The speaker assembly shall include the following components:

    a. Loudspeaker: Quam model 8C5PAX
    b. Transformer: Integral to unit, 5W, 25 and 70.7V, 5 taps
    c. Enclosure: SE1WVP
    d. Baffle: BS8W

3. The loudspeakers shall include the following audio features:

    a. Average Sensitivity: 92 dB-SPL, 1W / 1M
    b. Power rating: 12W-RMS, EIA 426A Standard
    c. Calculated Output: 99dB-SPL, 5W/ 1M
    d. Frequency Response: 65 Hz -17kHz EIA 426A Standard
    e. Nominal Coverage Angle: 90° Included Angle, -6dB/2kHz, Half Space
    f. Audio Connection: 7” long, color-coded tinned wires, pre-cut

E. Loudspeakers – Flush Mount:

1. Quam model SOLUTION 1, or equivalent by Lowell
2. The speaker assembly shall include the following components:

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a. Loudspeaker: Quam model 8C10PAX
b. Transformer: Integral to unit, 5W, 25 and 70.7V, 5 taps
c. Back Box: ERD8U
d. Baffle: BR8WS
e. Mounting Device SSB-3

3. The loudspeakers shall include the following audio features:

a. Average Sensitivity: 95 dB-SPL, 1W / 1M
b. Power rating: 20W-RMS, EIA 426A Standard
c. Calculated Output: 102dB-SPL, 5W/ 1M
d. Frequency Response: 60 Hz -17kHz EIA 426A Standard
e. Nominal Coverage Angle: 90° Included Angle, -6dB/2kHz, Half Space
f. Audio Connection: 7” Color Coded Leads

2.5 ACCESSORIES

A. Manufacturer:

1. Harding Instrument Co. Ltd.

B. Quick Connect Boards and Interface Cables:

1. Harding Instruments model QCB-120-1 with model CBL-STN-XX-RR interface cable for audio.
2. Harding Instruments model QCB-120-2 with model CBL-SWT-XX-RR interface cable for switches.
3. The quick connect board shall include the following features:

a. Dimensions: 3.25” x 4.28” x 1.5”
b. Intercom station field connections: Screw clamp terminals
c. Exchange field connections: double ended cable

4. The SSI shall provide the required number of quick connect boards and interface cables for all intercom stations and ceiling speakers in the system.

C. Page Zone Expander:

1. Harding Instruments model PZE-110-0
2. The page zone expander shall include the following features:

a. Dimensions: 1.75” x 19” x 16.13”
b. General Features: Three relay-controlled paging inputs with six relay-controlled page outputs for each input. Screw terminal connections for both page inputs and outputs. Sixteen supervised input lines. Three status LEDs for “run”, “install” and “fault”.
c. Operating Temperature: 32 to 122° F
d. Storage Temperature: -40 to 158° F
e. Humidity: 0 to 95% non-condensing
f. Power Requirements: 95-135 VAC, 47-63 Hz, 150mA MAX

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g. Paging Inputs: Maximum power; 100W max @ 25 Vrms per bank
h. Paging Outputs: Maximum power; 50W max @ 25 Vrms per channel
i. Standards: FCC Part 15, UL, CSA

3. The SSI shall provide the required number of PZE-110-0 units to support paging zones as shown on the plans.

D. Talkback Expander:

1. Harding Instruments model TBE-310
2. The talkback expander shall include the following features:

a. Dimensions: 1.75” x 19” x 16.13”
b. General Features: 8 amplified outputs that can drive 25 Vrms loudspeaker circuits, 5.0 watts output per channel, adjacent channels can be bridged to obtain higher power, from 2 to 8 channels can be bridged to form a group, up to 4 groups can be formed, loudspeakers can operate in talkback mode, USB connection to exchange, 2 type A and 1 type B USB ports.
c. Operating Temperature: 32 to 122° F
d. Storage Temperature: -40 to 158° F
e. Humidity: 0 to 95% non-condensing
f. Power Requirements: 95-135 VAC, 47-63 Hz, 1.25A
g. Paging Outputs: Maximum power; 5W max @ 25 Vrms per channel
h. Standards: FCC Part 15, UL, CSA

3. The SSI shall provide the required number of TBE-310 units to support paging zones as shown on the plans.

E. Intercom Pedestal:

1. The intercom pedestal shall include the following features:

a. Material: 12-gauge steel, powder-coated yellow
b. Minimum Dimensions: 72” (H) x 8” (W) x 8” (D)
c. Mounting: Designed to mount to flat pavement. Unit shall be secured to pavement with a minimum of 4 lag bolts.
d. Intercom Stations: Unit shall include three integral 2-gang back boxes for mounting two weatherproof intercom stations and a fixed dome camera.
e. Site-located pedestals at gate locations shall include an additional 1-gang back box for mounting a proximity reader.

2.6 AUDIO RECORDING SYSTEM

A. Manufacturer:

1. Eventide

B. Description: An audio recording system shall be provided to interface with the IP audio communication system. One channel of recording shall be provided for each audio master

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station location (GUI touchscreen master modules, VoIP telephone masters, etc.) in the system. The basis for the specification is Eventide.

C. Audio Recording System:

1. Eventide model NexLog740DX.
2. Recording system shall passively receive IP streams from IP audio system.
3. System shall provide G.711 encoded audio for clear and intelligible recordings.
4. Called party, calling party, time and duration shall be provided for search, analysis and retrieval.
5. System shall include browser-based HTML5 interface for search, replay, incident reconstruction, incident export, live monitoring and instant recall functionality.
6. The audio recorder shall include the following features:

a. Form Factor: 3U rack-mountable
b. CPU: Core i5
c. RAM: 16GB DDR4
d. NIC: (2) 100/1000 ports
e. Drives: 2 x 1TB fixed-mount HDDs (configured RAID1)
f. OS: Embedded Linux
g. Software: NexLog DX-Series software & MediaWorks DX web-based configuration manager with licenses for 8 concurrent users.
h. Front Panel: Audio controls and amplified speaker
i. Power: Dual hot-swap 120-240VAC 50/60Hz
j. Recording Channels: Provide 1 recording channel per each audio master station location.

EXECUTION

2.7 EXAMINATION

A. Verify the accuracy of all dimensions, allowances, and clearances on site prior to commencing with any work that may be affected by those dimensions, allowances, and clearances.

B. Comply with manufacturer’s installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

C. Precautions shall be taken to guard against electrostatic and electromagnetic susceptibility and interference.

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

2.8 INSTALLATION

A. Provide complete IP audio communication system as specified herein.

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B. All material furnished shall be new and conform to the applicable requirements of the Underwriters Laboratories and the National Standards Institute.

C. All system equipment to be contained within equipment racks or cabinets.

D. Provide adequate ventilation for all heat radiating equipment. SSI shall provide fan kits as required to maintain rated operating temperature of installed equipment.

E. All system equipment and field devices to be held securely in place. Fastenings and supports shall be selected to provide a safety factor of three.

F. All system equipment equipped with plug in power connectors to be connected to a dedicated receptacle. Do not use tap connectors for plugging in multiple plugs into a single receptacle.

G. All cable within equipment racks, and cabinets, or on backboards, to be neatly bundled and secured.

H. Wires shall not be nicked, have strands removed, or have frayed strands when removing insulation or terminating.

I. Wiring shall be executed in strict adherence to standard broadcast practices.

J. All field device cables terminating to quick connector boards shall be labeled for easy identification.

2.9 CONNECTIONS

A. All IP audio communication system equipment connections shall be completed per manufacturer’s recommendations and per SSI shop drawings.

B. Ground equipment according to manufacturer’s recommendations.

2.10 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust IP audio communication system 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 pass/fail reports:

1. Intercom station inspection: SSI shall perform an inspection of each intercom station to ensure that each station pushbutton works correctly and that the volume of the speaker is adjusted to the optimum level.
2. Audio master stations shall be tested for proper operation.
3. Ceiling speakers with audio threshold detection shall be tested for proper operation.

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

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2.11 ADJUSTING

A. SSI shall provide IP audio communication system configuration and adjustments. All intercom stations, loudspeakers and audio master stations shall be adjusted for optimum performance.

B. Occupancy Adjustments: Refer to specifications 280500, 3.5B.

2.12 DEMONSTRATION

A. Provide qualified personnel to train Owner's maintenance personnel to adjust, operate, and maintain the IP audio communication system. Refer to Division 01 Section "Demonstration and Training."

B. Training shall be video recorded.

END OF SECTION 28 51 23

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SECTION 31 05 13

SOILS FOR EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Subsoil materials.
   2. Topsoil materials.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:
   1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:
   1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   3. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

1.3 SUBMITTALS

A. None required.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

PART 2 PRODUCTS

2.1 SUBSOIL MATERIALS

A. Subsoil Type S1: Conforming to local standard.

B. Subsoil Type S2:
   1. Excavated and re-used material.
   2. Graded.
   3. Free of lumps larger than 3inches, rocks larger than 2inches, and debris.
   4. Conforming to ASTM D2487 Group Symbol CL.

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2.2 TOPSOIL MATERIALS

A. Topsoil Type S3: Conforming to local standard.

B. Topsoil Type S4:
   1. Excavated and reused material.
   2. Graded.
   3. Free of roots, rocks larger than ½ inch, subsoil, debris, large weeds and foreign matter.
      a. Screening: Single screened.

C. Topsoil Type S5:
   1. Imported borrow.
   2. Friable loam.
   3. Reasonably free of roots, rocks larger than ½ inch, subsoil, debris, large weeds, and foreign matter.
      a. Screening: Single screened.
   4. Acidity range (pH) of 5.5 to 7.5.
   5. Containing minimum of 4 percent and maximum of 25 percent inorganic matter.

2.3 SOURCE QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Testing and Inspection Services Testing and analysis of soil material.

B. Testing and Analysis of Subsoil Material: Perform in accordance with ASTM D1557.

C. Testing and Analysis of Topsoil Material: Perform in accordance with ASTM D1557.

D. When tests indicate materials do not meet specified requirements, change material and retest.

E. Furnish materials of each type from same source throughout the Work.

PART 3 EXECUTION

3.1 EXCAVATION

A. Excavate subsoil and topsoil from areas designated. Strip topsoil to full depth of topsoil in designated areas.

B. Stockpile excavated material meeting requirements for subsoil materials and topsoil materials.

C. Remove excess excavated subsoil and topsoil not intended for reuse, from site.

D. Remove excavated materials not meeting requirements for subsoil materials and topsoil materials from site.

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3.2 STOCKPILING

A. Stockpile materials on site as directed by Contractor.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Stockpile topsoil 8 feet high maximum.

E. Prevent intermixing of soil types or contamination.

F. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

G. Stockpile unsuitable materials on impervious material and cover to prevent erosion and leaching, until disposed of.

3.3 STOCKPILE CLEANUP

A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

B. When borrow area is indicated, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

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SECTION 31 05 16

AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Coarse aggregate materials.
   2. Fine aggregate materials.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Aggregate:
   1. Basis of Measurement: By cubic yard.
   2. Basis of Payment: Includes supplying aggregate materials, stockpiling.

1.3 REFERENCES

A. American Association of State Highway and Transportation Officials:
   1. AASHTO M147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.
   2. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:
   1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   3. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   4. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   5. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.4 SUBMITTALS

A. None required.

1.5 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

B. Perform Work in accordance with local standard.

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PART 2 PRODUCTS

2.1 COARSE AGGREGATE MATERIALS

A. Coarse Aggregate Type A1: Conforming to local standard.

B. Coarse Aggregate Type A2 (Gravel): AASHTO M147, Grade 2; passing No. 2 sieve with liquid limit of not more than 25; plasticity index of not more than five in accordance with ASTM D4318.

C. Coarse Aggregate Type A3 (Gravel): Crushed: natural washed stone; free of shale, clay, friable material and debris; graded in accordance with ASTM C136, Group Symbol GW; within the following limits:

Sieve Size	Percent Passing
2 inches (50 mm)	100
1 inch (25 mm)	95
3/4 inch (19 mm)	95 to 100
5/8 inches (16 mm)	75 to 100
3/8 inches (10 mm)	55 to 85
No. 4 (4.75 mm)	35 to 60
No. 16 (1.18 mm)	15 to 35
No. 40 (425 micro m)	10 to 25
No. 200 (75 micro m)	5 to 10

D. Aggregate Type A4 (Pea Gravel): Natural stone; washed, free of clay, shale, organic matter; graded in accordance with ASTM C136 ; to the following limits:
   1. Minimum Size: ¼ inch.
   2. Maximum Size: 5/8 inch.

2.2 FINE AGGREGATE MATERIALS

A. Fine Aggregate Type A5: Conforming to local standard.

B. Fine Aggregate Type A6 (Sand): Natural river or bank sand; washed; free of silt, clay, loam, friable or soluble materials, and organic matter; graded in accordance with ASTM C136; within the following limits:

Sieve Size	Percent Passing
No. 4 (4.75 mm)	100
No. 14 (1.4 mm)	10-100
No. 50 (300 micro m)	5 to 90
No. 100 (150 micro m)\	4 to 30

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No. 200 (75 micro m)	0

2.3 SOURCE QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Testing and inspection services.

B. Coarse Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D1557.

C. Fine Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D1557.

D. When tests indicate materials do not meet specified requirements, change material and retest.

PART 3 EXECUTION

3.1 EXCAVATION

A. Excavate aggregate materials from on-site locations indicated designated by Contractor.

B. Stockpile excavated material meeting requirements for coarse aggregate materials and fine aggregate materials.

C. Remove excess excavated coarse aggregate materials and fine aggregate materials not intended for reuse, from site.

D. Remove excavated materials not meeting requirements for coarse aggregate materials and fine aggregate materials from site.

3.2 STOCKPILING

A. Stockpile materials on site at locations as directed by Contractor.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate different aggregate materials with dividers or stockpile individually to prevent mixing.

D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

E. Stockpile unsuitable materials on impervious material and cover to prevent erosion and leaching, until disposed of.

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3.3 STOCKPILE CLEANUP

A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

B. When borrow area is indicated, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

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SECTION 31 10 00

SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Removing surface debris.
2. Removing designated paving and curbs.
3. Removing designated trees, shrubs, and other plant life.
4. Removing abandoned utilities.
5. Excavating topsoil.

1.2 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data for herbicide. Indicate compliance with applicable codes for environmental protection.

1.3 QUALITY ASSURANCE

A. Conform to applicable code for environmental requirements, disposal of debris, and use of herbicides.

B. Perform Work in accordance with local standards.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify existing plant life designated to remain is tagged or identified.

C. Identify waste area and/or salvage area for placing removed materials.

3.2 PREPARATION

A. Call Local Utility Line Information service not less than three working days before performing Work.

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1. Request underground utilities to be located and marked within and surrounding construction areas.

3.3 PROTECTION

A. Locate, identify, and protect utilities indicated to remain, from damage.

B. Protect trees, plant growth, and features designated to remain, as final landscaping as specified in Section 01 50 00 - Temporary Facilities and Controls.

C. Protect bench marks, survey control points, and existing structures from damage or displacement.

3.4 CLEARING

A. Clear areas required for access to site and execution of Work.

B. Remove trees and shrubs indicated. Remove stumps, main root ball, root system to depth of 24 inches, and surface rock.

C. Clear undergrowth and deadwood, without disturbing subsoil.

D. Apply herbicide to remaining stumps to inhibit growth.

3.5 REMOVAL

A. Remove debris, rock, and extracted plant life from site.

B. Remove paving and curbs.

C. Neatly saw cut edges at right angle to surface any paving to remain.

D. Remove abandoned utilities. Indicated removal termination point for underground utilities on Record Documents.

E. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.

F. Do not burn or bury materials on site. Leave site in clean condition.

3.6 TOPSOIL EXCAVATION

A. Excavate topsoil from areas to be further excavated, relandscaped, or regraded, without mixing with foreign materials for use in finish grading.

B. Do not excavate wet topsoil.

C. Stockpile in area designated on site to depth not exceeding 8 feet and protect from erosion. Stockpile material on impervious material and cover over with same material, until disposal.

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D. Remove excess topsoil not intended for reuse, from site.

END OF SECTION

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SECTION 31 20 00

EARTHWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. Excavation, hauling, embankment construction and compaction not covered by other items. The construction shall be in accordance with the Specifications and in close conformance with the lines, grades, and consideration of all pavement thicknesses shown on the Drawings or established by the Owner. All excavation will be classified as hereafter described.

1.2 CLASSIFICATION

A. Uniformity Coefficient: Used in this Specification as defined by ASTM D2487.

B. Plasticity Index: Used in this Specification as defined by ASTM D4318.

C. Zone of Influence: Used in this Specification to delineate the boundaries of a soil mass beneath a soil supported element that contributes to the support of the element. The Zone of influence is defined by imaginary lines extending outward and downward on a one (vertical) to one (horizontal) slope from line five feet outside the base perimeter of the supported element.

D. Topsoil Excavation: Excavation of sandy loam, sandy clay loam or clay loam from within the topsoil stripping limits that is suitable for use as topsoil.

E. Unsuitable Material Excavation: Mass excavation of unsuitable materials from within the zone of influence that is not suitable for the support of foundations, floor slabs and other elements.

F. Common Excavation: Common excavation shall consist of all excavation not included as rock excavation or excavation which is otherwise classified and paid for, including flexible type pavement and all rippable materials.

G. Rock Excavation: Rock excavation shall consist of igneous, metamorphic, and sedimentary rock which cannot be excavated without blasting; the use of a modern power shovel of no less than one cubic yard (.84 cubic meter) capacity, properly used, having adequate power and in good running condition; or the use of other equivalent powered equipment. It shall also include all boulders or other detached stones each having a volume of 1/2 or a cubic yard (0.38 of a cubic meter) or more.

H. Unclassified Excavation: Unclassified excavation shall consist of the excavation and disposal of all materials to whatever character encountered in the work.

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I. Structural Fill: Approved borrow material obtained from on-site stockpile and/or excavations required for backfilling and embankment construction within the zone of influence and meeting the specified material requirement.

J. General Fill: Approved material obtained from common excavation, unsuitable material excavation, and off-site borrows locations if necessary for backfilling and embankment construction in all areas not within the zone of influence and meeting the specified material requirements.

1.3 QUALITY ASSURANCE

A. Testing and inspection services to be provided by the contractor.

1.4 REFERENCES

A. American Society of Testing and Materials (ASTM) Publications:

1.	ASTM C977	Quicklime and Hydrated Line for Soil Stabilization
2.	ASTM D422	Particle Size Analysis of Soils
3.	ASTM D1556	Density and Unit Weight of Soil In Place by the Sand Cone Method
4.	ASTM D1557	Laboratory Compaction Characteristics of Soil Using Modified Effort
5.	ASTM D854	Specific Gravity of Soil Solid by Water Pycnometer
6.	ASTM D2167	Density and Unit Weight of Soil in Place by the Rubber Balloon Method
7.	ASTM D2216	Water (Moisture) Content of Soil and Rock by Mass
8.	ASTM D2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
9.	ASTM D3017	Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

B. Indiana Department of Transportation (INDOT) Publication: Standard Specifications latest edition.

1.5 DUST CONTROL

A. The Contractor shall comply with the requirements of 326 IAC 6-4 for fugitive dust.

B. The Contractor shall take adequate measures to control dust on the site. The Contractor shall have on the site an adequate number of watering vehicles to control dust by his operations.

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PART 2 - PRODUCTS

2.1 EXCEPT AS OTHERWISE NOTED HEREIN, THE FOLLOWING MATERIALS SHALL BE PROVIDED AS SPECIFIED IN THIS SECTION.

A. Structural backfill material shall be:

1. Sand and gravel or crushed stone with two (2) inch maximum particle size and containing no more than eight (8) percent by weight passing a No. 200 sieve. In addition, the uniformity coefficient shall be greater than four (4). The liquid limit shall not be greater than 25 and the plasticity index not more than 6.
2. Lime stabilized material.
3. On-site clays and silts or mixtures thereof, free of organic matter when dried to moisture contents compatible with required compaction levels.

B. General fill material is defined as a soil material that conforms to the following:
1. Contains no more than five (5) percent organic material and is free of trash, rubble, or other man-made objects.
2. On-site clays, silts and sands that contain less than 2% organic material.

C. "B" borrow shall be clean granular material complying with Section 211.02 of the INDOT Standard Specifications latest edition.

D. Quicklime and hydrated lime shall conform to ASTM C977.

PART 3 - EXECUTION

3.1 GENERAL

A. Excavations and embankments shall be finished to reasonably smooth and uniform surfaces. No materials shall be wasted without permission. Excavation operations shall be conducted so that material outside the limits of slopes will not be disturbed. Prior to beginning excavation, grading, embankment operations in any area, all necessary clearing, and grubbing and topsoil removal in that area shall have been performed.
1. All spongy and yielding material which will not readily compact when approximately dry and all vegetation shall be removed from within clearing limits and to such depths as ordered. None of this removed material shall be used in embankments.

B. When the Contractor performs grading operations after daylight hours, he shall provide and maintain at his expense sufficient artificial lighting to permit proper construction and inspection.

C. Grading operations shall be kept well in advance of paving operations in order to

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take advantage of maximum time for settlement.

D. The roadway and embankments shall be kept well drained at all times by keeping the center higher than the sides and uniformly graded. If necessary, temporary drainage ditches shall be provided as directed.

E. The Contractor shall employ one or a combination of the following for subgrade preparation for pavement:
1. Compaction of subgrade and embankments to 95% Modified Proctor (ASTM D1557).
2. Compaction of lime stabilized subgrade and embankments to 95% Modified Proctor (ASTM D1557).

F. The Contractor shall employ one or a combination of the following options for subgrade preparation under buildings in embankment areas only.
1. Compaction of subgrade and embankments to 95% Modified Proctor five feet beyond the proposed outside of the building. Compaction shall extend to subgrade at 0.5 horizontal to 1.0 vertical.
2. Compaction of lime stabilized subgrade and embankments to 95% modified proctor five feet beyond the proposed outside of the building. Compaction shall extend to subgrade at 0.5 horizontal to 1.0 vertical.

3.2 DEWATERING AND SURFACE WATER CONTROL

A. Where the excavation extends below the groundwater level, the Contractor shall provide, operate and maintain dewatering equipment necessary to maintain a dry excavation unless otherwise allowed by the Engineer. The dewatering method shall be activated to lower the water level below the established excavation level before the excavation reaches that level. The dewatering method shall not disturb the density of the subgrade soils. Dewatering shall be continued until all work below the groundwater table is completed and it is assured that the cession of dewatering will have no detrimental effect on any aspect of the project or until upon the written request of the Contractor, the Engineer gives written consent to cease dewatering operations. Dewatering shall then be discontinued gradually at a rate not to exceed 25 percent of the pumping capacity every three days or equivalent until all dewatering has ceased unless otherwise allowed in writing by the Engineer.

B. The Contractor shall keep the site free of standing water. The Contractor shall construct all necessary temporary ditches, swales and other means to keep stormwater away from work. When the permanent storm drainage system or portions thereof are constructed, stormwater shall be directed to the permanent stormwater collection systems. Upon completion of the work and anytime necessary during construction operations, the permanent stormwater collection system shall be cleaned of all sediment or debris which may enter the system.

C. The Contractor shall provide sufficient pumps to dewater all areas of the site where excavations are made or fills are placed in such a manner that creates a

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sump or depression that may hold water.

3.3 EXCAVATION

A. Excavation slopes shall be maintained in a stable condition at all times and shall not be steeper than 1.5 horizontal to 1 vertical unless proper precautions, as stipulated by OSHA, are taken.

B. The base of the excavation shall be protected against any damage, which affects the strength and compressibility characteristics of the exposed soil. Factors, which may damage the exposed excavation, are freezing, groundwater seepage inflow, equipment traffic, etc.

C. Surplus common excavation material shall be disposed of at locations as directed by the Owner.

3.4 EMBANKMENT AND COMPACTION

A. Embankment construction shall consist of constructing all embankments, including preparation of the areas upon which they are to be placed; the placing and compacting of approved material within embankment areas; and the placing and compacting of embankment material in holes, pits, and other depressions within the embankment area. Only approved materials shall be used in the construction of embankment backfill.

B. After the embankment area has been cleared and before embankment is placed, the building areas and areas to be paved shall be proofrolled prior to compaction of the subgrade and placement of any structural fills. All pronounced depressions left in the original ground surface by removal of objectionable material from within embankment limits shall be refilled with suitable material well compacted to the same density as required for the above embankment. Isolated soft pockets that are located during the proofrolling phase of this project shall be excavated and replaced with structural backfill. The material removed from the soft pockets shall be disposed of off site or re-used as fill material in yard areas only. The Contractor shall identify such replacement of soft pockets. Replacement shall proceed only when authorized prior to proceeding with the work. The upper 6 inches of the original ground shall be compacted with a 3-wheel roller weighing no less than 10 tons, or with other approved compacting equipment to the same density as required for the above embankment, unless otherwise directed by the Architect/Engineer. Subgrade compaction requirements shall be as follows:

1. Underneath and five feet out from the limits of:
   a. All buildings.
   b. All areas to receive paving
   95% Modified Proctor (ASTM D1557)
2. All other areas: 95% Modified Proctor (ASTM D1557)

C. Frozen materials, stumps, roots, all or parts of trees, brush, weeds, or other

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perishable materials shall not be placed in any embankment. Stones greater than 4 inches in any dimension shall not be left within 6 inches of the finished subgrade. The original ground surface or the surface of any lift in place shall not be frozen and shall be free from objectionable quantities of snow, ice or mud.

D. The embankment material shall be placed in uniform level layers, left properly shaped as set out above, and compacted with approved compacting equipment.

E. Each lift shall be disked or treated by some other mechanical means that will insure the breaking up on any existing lumps and clods.

F. The loose depth of each lift shall be such that the required compaction can be obtained, but in no case shall it exceed 8 inches. Where a tamping roller is used, the loose depth of lift shall not exceed the length of the tamper feet. The surface area of the end of each foot of the tamping roller shall be no less than 5-1/2 square inches.

G. In places inaccessible to motorized compacting equipment the required compaction shall be obtained with approved mechanical tamps or vibrators, in which case the depth of lifts, loose measurement, shall not exceed 6 inches.

H. If the embankment material is too wet and the compaction is not satisfactory, the material shall be aerated to remove excess moisture. Excess moisture shall be that which is above optimum moisture. When the material is too wet, the Owner shall make sufficient moisture tests to determine the amount of excess moisture to be removed by aeration and to further determine that the excess moisture has been removed. In addition to the density requirements set out herein, all embankments shall be constructed satisfactorily.

I. Only structural backfill material shall be used beneath footings, floor slabs and other foundations and shall extend outward away from the base of the foundation element at a 1:1 slope. Structural backfill material shall be placed adjacent to all structural walls for a minimum horizontal distance of two feet from the exterior of the walls and shall be placed to an elevation eighteen inches below finished grade. A clay cap shall then be placed above the structural backfill placed adjacent to the walls. Structural backfill material shall also be placed to a minimum depth of twelve inches beneath footings, floor slabs and other foundation elements.

J. General fill material can be used in areas not defined in Item I above unless otherwise noted on the Drawings.

K. No fill shall be placed against any structure until placed concrete has been allowed to cure for at least 3 days. Backfill shall be placed in such a manner that the structure will not be damaged by shock from falling earth. Special precautions shall be taken to prevent wedging action of filling material against structures. Heavy equipment for spreading and compacting shall not operate closer to foundation walls than set forth as follows:

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1. Fill placed adjacent to vertical or near vertical walls (within a zone defined by imaginary lines extending horizontally away from the base of the wall for a distance of 3 feet and thence upward and outward on a 1 to 1 slope to the elevation of the top of the wall) shall be compacted to the specified density with light equipment not exceeding 1500 pounds in static weight or dynamic rated impact.

L. All fill shall be of an approved material starting on an approved subgrade. Each lift shall be compacted to a dry density not less than the following percentage of maximum dry density determined by the Modified Proctor Test (ASTM D1557):

USAGE	**COMPACTION %**
Beneath footings, foundation slabs (limit based upon 5 feet from footing or foundation slab and extruding outward at a 45 degree angle to natural ground surface)	95
Beneath future building slabs on grade	95
Beneath piping	95
Unreinforced subgrade and embankment beneath pavements and sidewalks	95
Adjacent to and over piping except in paved areas	95
Adjacent to (or behind) vertical walls	95
Landscaping fill	90

3.5 SUBGRADE PREPARATION

A. General: Subgrade shall be shaped to line, grade, and cross section, and compacted as specified. This operation shall include plowing, disking, and any moistening, aeration, or other operation required to obtain specified compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory excavated material or other approved material as directed. Low areas resulting from removal of unsatisfactory material shall be brought up to required grade with satisfactory materials, and the entire subgrade shall be shaped to line, grade, and cross section and compacted as specified.

After rolling, the surface of the subgrade for the roadways shall not show deviation greater than 3/8-inch when tested with a 10 foot straightedge applied both parallel and at right angles to the centerline of the area. The elevation of the finished subgrade shall not vary more than 0.05 foot from the established grade

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and cross section.

B. Compaction: Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment well suited to the type of material being compacted.

C. Granular Fill Material Installation:
1. The aggregate subbase and base shall be properly installed before the Contractor may apply dual wheel loads of 9,000 pounds or above.

3.6 SINKHOLE TREATMENT

A. When evidence of a sinkhole feature is found, the debris and soft material present in the hole should be excavated. The excavation should proceed down to the rock surface, and the rock surface should be explored to identify any signs of a “throat” or significant void in the rock. If such a feature is encountered, the void should be covered with rocks large enough to span the opening. If a distinct throat is not found, the bottom of the excavation should be covered with rip-rap or similarly sized rock.

The sides of the excavation should be lined with a non-woven needlepunched filter fabric to cover the exposed soil faces. After the fabric is in place, a graded filter should be constructed over the large stone at the bottom of the hole. The filter should consist of a layer of No. 3 stone or similar material, overlain by No. 57 stone, with a top layer of dense graded aggregate. The thickness and placement of the aggregate layers should be determined at the time of treatment, based on the size of the excavation and various other factors. The filter fabric should be draped over to cover the dense-graded aggregate layer. A layer of clay, at least 3 feet thick, placed in lifts of no more than 8 inches, and compacted to at least 98 percent of the maximum dry density of the material, should be constructed over the filter to seal the hole.

3.7 STAGING PREPARATION

A. A Type "O" compacted aggregate base with a minimum depth of 6 inches shall be constructed over compacted subgrade for all roads and parking lots to be used for construction staging and beneath the floor slabs of the proposed buildings in this contract. The Type "O" compacted aggregate base placed beyond the building face shall be removed and disposed of on-site at an area set aside for this purpose by the Contractor and approved by the Engineer. Compacted aggregate base under the building shall have a minimum depth of 6 inches and a maximum depth of 8 inches and shall slope at 0.5 percent northeast southwest to drain. The construction of the Type “O” compacted aggregate base shall be in compliance with all applicable provisions of Section 303.05 through 303.12 and 303.14 of the INDOT Standard Specifications latest edition.

3.8 PROTECTION AND MAINTENANCE

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A. General: Protect newly graded areas from the actions of the elements. Any settlement or washing that occurs prior to acceptance of the work shall be repaired, and grades re-established to the required elevations and slopes. Fill to required subgrade levels in areas where settlement occurs.

B. Protect drive and parking area pavements from truck equipment or other vehicular traffic until base course of paving has been installed.

C. Maintain all of the work of this section as needed until the Owner has accepted the work.

D. It shall be the Contractor's responsibility to comply with all state and local pollution control ordinances and the requirements set out in these Specifications.

E. At the completion of the project all areas outside the work limits, disturbed by the Contractor during the execution of his work, shall be returned to as near its original condition as possible

3.9 LIME STABILIZATION

A. Where determined necessary by the Contractor and the Architect/Engineer, the top 12" of subgrade shall be lime stabilized and shall be disked or otherwise scarified. Lime shall then be thoroughly blended into the scarified subgrade material at the rate determined by the Contractor based upon the in-situ soils characteristics. The scarified material shall then be compacted using appropriate compaction equipment to the density specified.

B. It may be determined necessary by the Contractor and the Architect/Engineer to lime stabilize any new fill material that is too wet to otherwise compact. The Contractor shall spread the fill material in a uniform loose lift no thicker than 8 inches. The Contractor shall spread at the necessary rate lime uniformly over the fill surface and blend the lime with the wet fill material. The Contractor shall blend the lime and fill using a disk, a rotovator or other devices approved by the Owner’s Representative. The material shall then be compacted to the specified density.

C. The Contractor may elect to stabilize wet fill material on an independent mixing pad situated away from the area being filled. Should this technique be used, the Contractor shall spread the new fill and lime, and thoroughly mix the lime and fill material as described above. The blended fill shall then be picked up and moved to the area being filled, and compacted to the specified dry density. The Contractor shall be responsible for moving and compacting the blended fill material while the material is still workable. Fill mixed with lime and permitted to cure too long to be compacted to the specified dry density, shall be the responsibility of the Contractor.

D. If lime stabilization methods are employed, the Contractor shall have on-site, at all times, a water truck with suitable spreader system to aid in the lime

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stabilization process.

3.10 EMBANKMENT RECONSTRUCTION

A. Embankment improperly compacted shall be excavated to the depth directed by the Architect/Engineer and then refilled and compacted to the density specified at no additional cost to the Owner. Field in-place density tests shall also be repeated for improperly compacted embankments that are excavated, refilled and recompacted at no additional cost to the Owner.

END OF SECTION

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SECTION 31 22 13

ROUGH GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavating subsoil.
   2. Cutting, grading, filling, rough contouring, and compacting.

1.2 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported materials suppliers.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.3 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution Requirements: Requirements for submittals.

B. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Topsoil: Excavated material, graded free of roots, rocks larger than one inch, subsoil, debris and large weeds.

B. Subsoil Fill: Excavated material, graded free of lumps larger than 6 inches, rocks larger than 3 inches, land debris.

C. Structural Fill: Approved material, free of lumps, frozen soil, wood, topsoil or other deleterious material.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify survey bench mark and intended elevations for the Work are as indicated on Drawings.

3.2 PREPARATION

A. Call Local Utility Line Information service not less than three working days before performing Work.
   1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum.

C. Notify utility company to remove or relocate any utilities.

D. Protect utilities indicated to remain from damage.

E. Protect plant life, lawns, and other features remaining as portion of final landscaping.

F. Protect bench marks, survey control point, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.3 SUBSOIL EXCAVATION

A. Excavate subsoil from areas to be further excavated, relandscaped, or regraded.

B. Do not excavate wet subsoil or excavate and process wet material to obtain optimum moisture content.

C. When excavating through roots, perform Work by hand and cut roots with sharp axe.

D. Stockpile subsoil in area designated on site to depth not exceeding 12 feet and protect from erosion.

E. Benching Slopes: Horizontally bench existing slopes greater than 1: 4 to key placed fill material to slope to provide firm bearing.

F. Stability: Replace damaged or displaced subsoil as specified for fill.

3.4 FILLING

A. Fill areas to contours and elevations with unfrozen materials.

B. Place fill material in continuous layers and compact in accordance with schedule at end of this section.

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C. Maintain optimum moisture content of fill materials to attain required compaction density.

D. Slope grade away from building minimum 5 percent slope for minimum distance of 10 ft, unless noted otherwise.

E. Make grade changes gradual. Blend slope into level areas.

F. Repair or replace items indicated to remain damaged by excavation or filling.

3.5 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Top Surface of Subgrade: Plus or minus 1/10 foot from required elevation.

3.6 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.7 SCHEDULES

A. Structural Fill:
   1. Maximum 6 inches compacted depth.
   2. Compact uniformly to minimum 95 percent of maximum density.

B. Subsoil Fill:
   1. Maximum 8 inches compacted depth.
   2. Compact uniformly to minimum 95 percent of maximum density.

C. Topsoil Fill:
   1. Maximum 8 inches compacted depth.
   2. Compact uniformly to minimum 90 percent of maximum density.

END OF SECTION

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SECTION 31 23 16

EXCAVATION AND FILL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Soil densification.
   2. Excavating for building foundations.
   3. Excavating for paving, roads, and parking areas.
   4. Excavating for slabs-on-grade.
   5. Excavating for site structures.
   6. Excavating for landscaping.

1.2 REFERENCES

A. Local utility standards when working within 24 inches of utility lines.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.

C. Shop Drawings: Indicate soil densification grid for each size and configuration footing requiring soils densification.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 PREPARATION

A. Call Local Utility Line Information service not less than three working days before performing Work.
   1. Request underground utilities to be located and marked within and surrounding construction areas.

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B. Identify required lines, levels, contours, and datum.

3.2 EXCAVATION

A. Underpin adjacent structures which may be damaged by excavation work.

B. Excavate subsoil to accommodate building foundations, slabs-on-grade, paving, site structures, and construction operations.

C. Excavate to working elevation for piling work.

D. Compact disturbed load bearing soil in direct contact with foundations to original bearing capacity; perform compaction in accordance with Section 31 23 23 and Section 31 23 17.

E. Slope banks with machine to angle of repose or less until shored.

F. Do not interfere with 45 degree bearing splay of foundations.

G. Grade top perimeter of excavation to prevent surface water from draining into excavation.

H. Trim excavation. Remove loose matter.

I. Remove lumped subsoil, boulders, and rock up to 1/3 cu yd measured by volume. Remove larger material as specified in Section 31 23 23.

J. Notify Architect/Engineer of unexpected subsurface conditions.

K. Correct areas over excavated as specified in Section 31 23 23.

L. Stockpile subsoil in area designated on site to depth not exceeding 12 feet and protect from erosion.

M. Repair or replace items indicated to remain damaged by excavation.

3.3 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Perform inspection of excavation and controlled fill operations in accordance with applicable code.

C. Request visual inspection of bearing surfaces before installing subsequent work.

3.4 PROTECTION

A. Prevent displacement or loose soil from falling into excavation; maintain soil stability.

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B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.

C. Protect structures, utilities and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth operations.

END OF SECTION

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SECTION 31 23 17

TRENCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavating trenches for utilities from 5 feet outside building to utility service.
   2. Compacted fill from top of utility bedding to subgrade elevations.
   3. Backfilling and compaction.

1.2 REFERENCES

A. ASTM International:
   1. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

B. Indiana Department of Transportation (INDOT) Publication: Standard Specifications latest edition.

1.3 DEFINITIONS

A. Utility: Any buried pipe, duct, conduit, or cable.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.

C. Product Data: Submit data for geotextile fabric indicating fabric and construction.

D. Materials Source: Submit name of imported fill materials suppliers.

E. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

1.6 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

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1.7 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. Fill: Material free of lumps, frozen soil, wood, topsoil or other deleterious material.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All work shall conform to the requirements of all local, State and Federal agencies having jurisdiction and the requirements of these specifications.

B. Unless otherwise directed or permitted, not more than one hundred feet (100') of any trench shall be open at any time.

C. Surface encumbrances, located so as to create a hazard to employees involved in excavation work or in the vicinity thereof at any time during operations, shall be removed or made safe before excavating is begun.

D. During excavation, material satisfactory for backfilling shall be stockpiled in an orderly manner at a distance from the banks of the trench sufficient to avoid overloading and to prevent slides and cave-ins. Adequate drainage shall be provided for the stockpiles and surrounding areas by means of ditches, dikes, or other approved methods. The stockpiles shall also be protected from contamination with unsatisfactory excavated material or other material that may destroy the quality and fitness of the suitable stockpiled material.

If the Contractor fails to protect the stockpiles and any material becomes unsatisfactory as a result, such material, if directed by the Owner, shall be removed and replaced with satisfactory on-site or imported material from approved sources at no additional cost.

E. Grading shall be done as may be necessary to prevent surface water from flowing into the excavation, and any water accumulating therein shall be removed so that the stability of the bottom and sides of the excavation is maintained. In wet trenches dewatering equipment shall be operated ahead of pipe laying and the water level kept below the pipe invert.

F. The trench shall be excavated as shown on the Drawings or as recommended by the manufacturer of the pipe to be installed, whichever is more stringent. Trench walls below and above the top of the pipe shall be sloped, or made vertical, as

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recommended in the manufacturer's installation manual. The trench width below an elevation one foot above the top of pipe shall not exceed that recommended in the installation manual. Where no manufacturer's installation manual is available, trench walls below an elevation one foot above the top of pipe shall be vertical and trench walls one foot or more above the top of pipe shall be adequately sloped as required to prevent slides and cave-in unless proper precautions, as stipulated by OSHA, are taken. If adequate trench slopes are not or cannot be provided in the available contract limits, then use of sheeting and shoring and/or a trench box is mandatory.

G. Unless otherwise indicated, excavation shall be by open cut. However, sections of sewer lines under pavement or in locations where surface conditions make it difficult or impractical to excavate open trenches, installation shall be made by boring or jacking as a Contractor operation and subject to the Owner's review. All sewer pipes smaller than 36 inches in diameter which is installed by boring or jacking shall be installed in steel pipe casing.

H. Dust conditions shall be kept to a minimum by the use of water, salt, calcium chloride, or other means.

3.2 LINES AND GRADES

A. Lay pipes to lines and grades indicated on Drawings.
   1. Architect/Engineer reserves right to make changes in lines, grades, and depths of utilities when changes are required for Project conditions.

B. Use laser-beam instrument with qualified operator to establish lines and grades.

3.3 PREPARATION

A. Call Local Utility Line Information service not less than three working days before performing Work.
   1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Identify required lines, levels, contours, and datum locations.

C. Protect plant life, lawns, and other features remaining as portion of final landscaping.

D. Protect bench marks, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

E. Maintain and protect above and below grade utilities indicated to remain.

F. Establish temporary traffic control when trenching is performed in public right-of-way. Relocate controls as required during progress of Work.

3.4 TRENCHING

A. Excavate subsoil required for utilities to utility service.

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B. Cut trenches sufficiently wide to enable installation and allow inspection. Remove water or materials that interfere with Work.

C. Do not interfere with 45 degree bearing splay of foundations.

D. Hand trim excavation as necessary. Hand trim for bell and spigot pipe joints. Remove loose matter.

E. Remove lumped subsoil, boulders, and rock.

F. Correct areas over excavated.

G. As trenches are backfilled, the Contractor shall removal all surplus material, regrade and leave clear, free, and in good order all roadways and sidewalks affected by the construction of the work. During the progress of and until the expiration of the guarantee period, he shall maintain in good and safe conditions the surface or any street over the trenches and promptly fill all depressions over and adjacent to trenches caused by settlement of backfilling.

H. Stockpile excavated material in area designated on site and remove excess material not being used, from site.

3.5 COVERING ENDS

A. Before leaving the work for the night, during a storm, or for any other reason, care must be taken that the unfinished end of any pipe is securely closed with a tightly fitting cover or plug. Any earth or other material that may find entrance into the pipe, through any such open end of an unplugged pipe shall be removed at the Contractor's expense.

3.6 STABILIZATION

A. If portions of the bottom of trenches or excavations consist of material unstable to such a degree that, in the opinion of the Owner, it cannot adequately support the pipe or structure, the bottom shall be over excavated and stabilized with coarse aggregate Size No. 9 gravel in compliance with Section 904.02 of the INDOT Standard Specifications latest edition. Depth of stabilization shall be as directed by the Owner.

3.7 BACKFILLING

A. Backfill trenches to contours and elevations with unfrozen fill materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

C. Coarse Aggregate Size No. 9 and 11 gravel shall comply with Section 904.02 of the INDOT Standard Specifications latest edition.

D. Granular material, which is noted on the drawings as granular material or B-borrow, shall comply with Article 211.02 of the INDOT Standard Specifications latest edition.

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Maximum stone size shall not exceed 1 inch or the maximum size recommended by the pipe manufacturer, whichever is smaller.

E. Earth backfill material shall contain no more than 5% organic material, no particles larger than four inches and shall be free of trash, rubble and debris. The Plastic Index of the fraction passing the No. 40 sieve shall not be more than 25.

F. Crushed stone material shall be No. 53 complying with Section 904.02 of the INDOT Standard Specifications latest edition.

G. Employ placement method that does not disturb or damage utilities in trench.

H. Maintain optimum moisture content of fill materials to attain required compaction density.

I. Remove surplus fill materials from site.

J. Leave fill material stockpile areas completely free of excess fill materials.

K. Trenches shall be backfilled to existing grade or grades as shown on the Drawings.

L. Pipe bedding, haunching and initial backfill for aluminized type 2 corrugated steel pipe and reinforced concrete pipe shall be structural backfill or "B" borrow to a depth shown on the drawings. Such backfill shall be placed in lifts of a maximum of 6 inches thickness.

The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. Care shall be taken to ensure thorough compaction of the fill under pipe haunches.

M. Backfill for the remainder of the trenches shall be as follows:
1. Backfill for trenches in turfed or seeded areas and in miscellaneous areas shall be of approved earth material and contain no stones over four (4") in their largest dimensions. Stones that are used in backfilling shall be distributed among the earth backfill so that all interspace are filled with fine material. All such backfilling shall be deposited in lifts of a maximum 12 inches lose thickness and compacted by hand tamping or approved mechanical tamping devices. Excess earth to the amount required to replace settlement shall be neatly rounded over the trench and the remainder stockpiled where designated on the drawings or hauled off site. The Contractor shall maintain Trenches until settlement has ceased and trenches remain level with the adjacent ground.
2. Backfill of all trenches under structures and paved areas shall be structural backfill as classified. In addition, the top six inches (6") below the base of the pavement shall be backfilled with No. 53 stone. The backfill shall be placed in six-inch (6") maximum lifts and the method of placing and compacting the backfill shall comply with Article 211.04 of the INDOT Standard Specifications latest edition, as applicable.

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3.8 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Top Surface of Backfilling Under Paved Areas: Plus or minus 1inch from required elevations.

C. Top Surface of General Backfilling: Plus or minus 1inch from required elevations.

3.9 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Perform laboratory material tests in accordance with ASTM D1557.

C. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

3.10 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution Requirements: Protecting finished work.

B. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF SECTION

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SECTION 31 23 23

BACKFILL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Backfilling building perimeter to subgrade elevations.
2. Backfilling site structures to subgrade elevations.
3. Fill under slabs-on-grade.
4. Fill under paving.
5. Fill for over-excavation.

1.2 REFERENCES

A. Indiana Department of Transportation (INDOT) Publication: Standard Specifications latest edition.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data for geotextile fabric indicating fabric and construction.

C. Materials Source: Submit name of imported fill materials suppliers.

D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. Coarse Aggregate Size No. 9 and 11 gravel shall comply with Section 904.02 of the INDOT Standard Specifications latest edition.

B. Granular material, which is noted on the drawings as granular material or B-borrow, shall comply with Article 211.02 of the INDOT Standard Specifications latest edition. Maximum stone size shall not exceed 1 inch or the maximum size recommended by the pipe manufacturer, whichever is smaller.

C. Earth backfill material shall contain no more than 5% organic material, no particles larger than four inches and shall be free of trash, rubble and debris. The Plastic Index of the fraction passing the No. 40 sieve shall not be more than 25.

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D. Crushed stone material shall be No. 53 complying with Section 904.02 of the INDOT Standard Specifications latest edition.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Verify subdrainage, dampproofing, or waterproofing installation has been inspected.

C. Verify underground tanks are anchored to their own foundations to avoid flotation after backfilling.

D. Verify structural ability of unsupported walls to support loads imposed by fill.

3.2 PREPARATION

A. Compact subgrade to density requirements for subsequent backfill materials.

B. Cut out soft areas of subgrade not capable of compaction in place. Backfill and compact to density equal to or greater than requirements for subsequent fill material.

C. Scarify subgrade surface to depth of 8 inches.

D. Proof roll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

3.3 BACKFILLING

A. Backfill areas to contours and elevations with unfrozen materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces.

C. Place material in continuous layers as follows:
   1. Subsoil Fill: Place and compact material in equal continuous layers not exceeding 8 inches (200 mm) compacted depth.
   2. Granular Fill: Place and compact materials in equal continuous layers not exceeding 6 inches (150 mm) compacted depth.

D. Employ placement method that does not disturb or damage other work.

E. Maintain optimum moisture content of backfill materials to attain required compaction density.

F. Backfill against supported foundation walls. Do not backfill against unsupported foundation walls.

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G. Backfill simultaneously on each side of unsupported foundation walls until supports are in place.

H. Slope grade away from building minimum 5 percent slope for minimum distance of 10 ft, unless noted otherwise.

I. Make gradual grade changes. Blend slope into level areas.

J. Remove surplus backfill materials from site.

K. Leave fill material stockpile areas free of excess fill materials.

3.4 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Top Surface of Backfilling: Plus or minus 1 inch from required elevations.

3.5 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

C. Proof roll compacted fill surfaces under slabs-on-grade and paving.

3.6 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution Requirements: Protecting finished work.

B. Reshape and re-compact fills subjected to vehicular traffic.

END OF SECTION

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SECTION 31 25 13

EROSION CONTROL DEVICES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Erosion Control methods as shown on drawings.

1.2 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.3 QUALITY ASSURANCE

A. Perform Work in accordance with EPA General Permit.

PART 2 PRODUCTS

2.1 All material necessary to complete the work specified by this specification shall conform to the details shown in the plans, as specified below, and shall meet all requirements of any local or state agency having jurisdiction and their Standard Specifications.

PART 3 EXECUTION

3.1 SITE STABILIZATION

A. Incorporate erosion control devices indicated on the Drawings into the Project at the earliest practicable time.

B. Construct, stabilize and activate erosion controls before site disturbance within tributary areas of those controls.

C. Stockpile and waste pile heights shall not exceed 12 feet. Slope stockpile sides at 2: 1 or flatter.

D. Stabilize any disturbed area of affected erosion control devices on which activity has ceased and which will remain exposed for more than 20 days.
   1. During non-germinating periods, apply mulch at recommended rates.
   2. Stabilize disturbed areas which are not at finished grade and which will be disturbed within one year in accordance with Section 32 92 19 temporary seeding specifications.

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3. Stabilize disturbed areas which are either at finished grade or will not be disturbed within one year in accordance with Section 32 92 19 permanent seeding specifications.

E. Stabilize diversion channels, sediment traps, and stockpiles immediately.

3.2 FIELD QUALITY CONTROL

A. Inspect erosion control devices on a weekly basis and after each runoff event. Make necessary repairs to ensure erosion and sediment controls are in good working order.

B. When the temporary erosion control items specified herein are no longer required due to the advancement of construction operations, or evidenced by the successful establishment of soil holding ground cover, it shall be the responsibility of the Contractor to remove and dispose of all straw bales, stakes, fences, posts, filter fabric, silt, sediment and other associated materials and to regrade, shape and seed or sod the disturbed areas.

C. The Contractor and Owner shall have in their possession, an approved Erosion and Sediment Control Plan. The Contractor shall abide by its methods and those shown on the plans. Any non-compliance of the report shall be brought to the attention of the Engineer.

3.3 CLEANING

A. When sediment accumulation in sedimentation structures has reached a point one-third depth of sediment structure or device, remove and dispose of sediment.

B. Do not damage structure or device during cleaning operations.

C. Do not permit sediment to erode into construction or site areas or natural waterways.

D. Clean channels when depth of sediment reaches approximately one half channel depth.

END OF SECTION

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SECTION 32 11 23

AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Aggregate subbase.
   2. Aggregate base course.

1.2 REFERENCES

A. Indiana Department of Transportation (INDOT) Publication: Standard Specifications latest edition.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data:
   1. Submit data for geotextile fabric and herbicide.

C. Materials Source: Submit name of aggregate materials suppliers.

D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

B. Perform Work in accordance with local standards.

PART 2 - PRODUCTS

2.1 AGGREGATE MATERIALS

A. No. 2 subbase materials shall meet the gradation as set forth in Subsection 903.02, Course Aggregates, INDOT Standard Specifications latest edition.

B. No. 53 "Type O" subbase materials shall meet the gradation as set forth in the INDOT Standard Specifications latest edition.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify compacted substrate is dry and ready to support paving and imposed loads]

C. Verify substrate has been inspected, gradients and elevations are correct.

3.2 PREPARATION

A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.

B. Do not place fill on soft, muddy, or frozen surfaces.

3.3 AGGREGATE PLACEMENT

A. Spread aggregate over prepared substrate to total compacted thickness indicated on Drawings.

B. Place aggregate in maximum 6 inch layers and compact.

C. Level and contour surfaces to elevations, profiles, and gradients indicated.

D. Add small quantities of fine aggregate to coarse aggregate when required to assist compaction.

E. Maintain optimum moisture content of fill materials to attain specified compaction density.

F. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.4 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Maximum Variation From Flat Surface: 1/4 inch measured with 10 foot straight edge.

C. Maximum Variation From Thickness: 1/4 inch.

D. Maximum Variation From Elevation: 1/2 inch.

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3.5 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

END OF SECTION

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SECTION 32 12 16

FLEXIBLE PAVEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Asphalt paving base course, binder course, and wearing course.

1.2 REFERENCES

A. Asphalt Institute:
   1. AI MS-2 - Mix Design Methods for Asphalt Concrete and Other Hot- Mix Types.

B. Indiana Department of Transportation (INDOT) Publication: Standard Specifications latest edition.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data:
   1. Submit product information for asphalt and aggregate materials.
   2. Submit mix design with laboratory test results supporting design.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Mixing Plant: Conform to INDOT standards.

B. Obtain materials from same source throughout.

C. Perform Work in accordance with INDOT’s standards.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Section 01 60 00 - Product Requirements: Environmental conditions affecting products on site.

B. Do not place asphalt mixture when ambient air or base surface temperature is less than 40 degrees F, or surface is wet or frozen.

C. Place asphalt mixture when temperature is not more than 15 degrees F less than initial mixing temperature.

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PART 2 - PRODUCTS

2.1 ASPHALT MATERIALS

A. Asphalt Cement: INDOT AC20.

B. Aggregate for Base Course Mix: In accordance with State Department of Transportation standards.

C. Aggregate for Binder Mix: See Details.

D. Aggregate for Topping Mix: See Details.

E. Fine Aggregate: Manufactured sand.

F. Mineral Filler: Finely ground particles of limestone, hydrated lime or other mineral dust, free of foreign matter.

G. Tack Coat: Asphalt Emulsion AE-T.

2.2 MIXES

A. Use dry material to avoid foaming. Mix uniformly.

B. Asphalt Paving Mixtures:
1. Base Course: 4.5 to 6 percent of asphalt cement by weight in mixture.
2. Binder Course: 4.5 to 6 percent of asphalt cement by weight in mixture in accordance with AI MS-2.
3. Wearing Course: 5 to 7 percent of asphalt cement by weight in mixture. Topping course shall contain a minimum of 10 percent fine aggregate.

2.3 SOURCE QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Testing, inspection and analysis requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify utilities indicated under paving are installed with excavations and trenches backfilled and compacted.

C. Verify compacted granular subbase is dry and ready to support paving and imposed loads.

D. Verify gradients and elevations of base are correct.

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3.2 TACK COAT

A. Coat surfaces of manhole and catch basin frames with oil to prevent bond with asphalt paving. Do not tack coat these surfaces.

3.3 ASPHALT PAVING

A. Install Work in accordance with INDOT standards.

B. Place each course to compacted thickness identified on Drawings.

C. Place tack coat at a rate of 0.05 gallons per square yard where new paving will cover existing paving.

D. Place binder course.

E. Place topping course within twenty-four hours of placing and compacting binder course.

F. Compact paving by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.

G. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.

3.4 ERECTION TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Flatness: Maximum variation of 1/4 inch measured with 10 foot straight edge.

C. Scheduled Compacted Thickness: Within 1/4 inch.

D. Variation from Indicated Elevation: Within 1/2 inch.

3.5 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Asphalt Paving Mix Temperature: Measure temperature at time of placement.

3.6 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution Requirements: Requirements for protecting finished Work.

B. Immediately after placement, protect paving from mechanical injury for 15 days or until surface temperature is less than 140 degrees F.

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END OF SECTION

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SECTION 32 13 13

RIGID PAVEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete paving for:
      a. Concrete sidewalks.
      b. Concrete curbs and gutters.

1.2 REFERENCES

A. American Concrete Institute:
   1. ACI 301 - Specifications for Structural Concrete.

B. ASTM International:
   1. ASTM A185/A185M - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
   2. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   3. ASTM C33 - Standard Specification for Concrete Aggregates.
   4. ASTM C150 - Standard Specification for Portland Cement.
   5. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   6. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
   7. ASTM C1371 - Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers.
   8. ASTM C1549 - Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer.
   9. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   10. ASTM E408 - Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques.
   11. ASTM E903 - Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres.
   12. ASTM E1918 - Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field.
   13. ASTM E1980 - Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

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B. Product Data:
   1. Submit data on concrete materials, joint filler, admixtures, and curing compounds

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with ACI 301.

B. Obtain cementitious materials from same source throughout.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Section 01 60 00 - Product Requirements: Environmental conditions affecting products on site.

B. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

A. Form Materials: Conform to ACI 301.

B. Joint Filler: ASTM D1751.

2.2 REINFORCING

A. Reinforcing Steel: ASTM A615; 40 ksi yield grade; deformed billet steel bars; galvanized finish.

B. Welded Steel Wire Fabric: Plain type, ASTM A185; in flat sheets or coiled rolls; galvanized finish.

C. Dowels: ASTM A615; 40 ksi yield grade, plain steel, galvanized finish.

D. Concrete used in sidewalk construction shall be reinforced with fiber reinforcement.
   1. Reinforcement shall be added at the time of mixing at a rate of one pound per cubic yard.
   2. Fiber shall be 3/4" length.
   3. Fibers shall conform to ASTM C1116-89 except that nylon fibers conforming to all other requirements of the standard may be used.

2.3 CONCRETE MATERIALS

A. Cement: ASTM C150 Normal - Type I Portland type, gray color.

B. Fine and Coarse Aggregates: ASTM C33.

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C. Water: Potable, not detrimental to concrete.

D. Air Entrainment: Add air-entraining agent as indicated in ACI 301 Table 3.4.1.

2.4 ACCESSORIES

A. Curing Compound: ASTM C309, Type 1; Promulsion-60 manufactured by Protex Industries, Inc.

2.5 CONCRETE MIX

A. Weight: Normal Weight.

B. Strength for concrete/paving: 4000 psi, 28 day compressive strength; minimum cement requirements in accordance with ACI 301, Table 3.8.5 lb. except not less than 520 pounds of cement per cubic yard.

C. Strength for Concrete Curbs, Gutters, and Walks: 4000 psi, 28-day compressive strength; minimum 520 pounds of cement per cubic yard.

D. Slump: In accordance with ACI 301; 3-inch maximum slump for concrete paving.

E. Proportions: Selection in accordance with ACI 301 Method 1, trial batches or Method 2, field test data.

2.6 SOURCE QUALITY CONTROL AND TESTS

A. Section 01 40 00 - Quality Requirements: Testing and Inspection Services.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify compacted granular subbase is dry and ready to support paving and imposed loads.

C. Verify gradients and elevations of base are correct.

3.2 PREPARATION

A. Moisten substrate to minimize absorption of water from fresh concrete.

B. Notify Architect/Engineer minimum 24 hours prior to commencement of concreting operations.

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3.3 FORMING

A. Place and secure forms and screeds to correct location, dimension, profile, and gradient.

B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

C. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

3.4 REINFORCING

A. Place reinforcing as indicated on Drawings.

B. Interrupt reinforcing at expansion joints.

C. Place dowels to achieve paving and curb alignment as detailed.

3.5 PLACING CONCRETE

A. Place concrete in accordance with ACI 301, 305, and 306.

B. Ensure reinforcing, inserts, embedded parts, and formed joints are not disturbed during concrete placement.

C. Place concrete continuously over the full width of the panel and between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

D. Place concrete to pattern indicated.

3.6 JOINTS

A. Place expansion joints at 50 foot intervals. Align curb, gutter, and sidewalk joints.

B. Place joint filler between paving components and building or other appurtenances. Recess top of filler 1/4 inch for sealant installation.

C. Provide scored or sawn joints at 5 feet intervals between sidewalks and curbs and between curbs and paving.

D. Saw cut contraction joints 3/16 inch wide at an optimum time after finishing. Cut 1/3 into depth of slab. Concrete pavement joints shall be constructed in accordance with the type dimensions and at the locations required by the plans unless directed otherwise by the Architect/Engineer. Concrete pavement joints shall comply with all applicable provisions of Section 501.14 of the INDOT Standard Specifications.
   1. The backer rod shown in the expansion joint detail shall be "Cera-rod" as manufactured by W.R. Meadows or an approved equal.
   2. The joint sealer shall be "Pourthane" as manufactured by W.R. Meadows or an approved equal.

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3.7 FINISHING

A. Paving: Light broom.

B. Sidewalk Paving: Light broom and trowel joint edges.

C. Curbs and Gutters: Light broom.

D. Direction of Texturing: Transverse to paving direction.

E. Place curing compound sealer on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's instructions.

3.8 JOINT SEALING

A. Separate pavement from vertical surfaces with 1/2-inch thick joint filler.

B. Place joint filler in pavement pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.

C. Extend joint filler from bottom of pavement to within 1/4 inch of finished surface.

3.9 ERECTION TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Maximum Variation of Surface Flatness: 1/4 inch in 10 ft.

C. Maximum Variation From True Position: 1/4 inch.

3.10 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect reinforcing placement for size, spacing, location, support.

3.11 PROTECTION

A. Immediately after placement, protect paving from premature drying, excessive hot or cold temperatures, and mechanical injury.

B. Do not permit vehicular traffic over paving for 7 days minimum after finishing or until 75 percent design strength of concrete has been achieved.

END OF SECTION

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SECTION 32 17 23

PAINTED PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Traffic lines and markings.
   2. Legends.
   3. Paint.

1.2 REFERENCES

A. Indiana Department of Transportation (INDOT) Publication: Standard Specifications latest edition.

1.3 PERFORMANCE REQUIREMENTS

A. Paint Adhesion: Adhere to road surface forming smooth continuous film one minute after application.

B. Paint Drying: Tack free by touch so as not to require coning or other traffic control devices to prevent transfer by vehicle tires within two minutes after application.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Invert containers several days prior to use when paint has been stored more than 2 months. Minimize exposure to air when transferring paint. Seal drums and tanks when not in use.

PART 2 - PRODUCTS

2.1 PAINTED PAVEMENT MARKINGS

A. Paint shall comply with Article 909.05 of the Standard Specification.

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2.2 EQUIPMENT

A. Paint equipment shall consist of a machine of the spray type capable of applying the paint directly to the pavement under pressure through a nozzle. The machine shall be equipped with an air blast device for cleaning the pavement ahead of the painting operation, a guide pointer to keep the machine on an accurate line, and a device to agitate the paint. It shall also have a device to maintain a uniform flow and application of the paint, an automatic device to provide a broken or skip line of the length required, and at least 2 spray guns capable of being operated individually or together. When using fast dry traffic paint, the equipment shall be capable of heating the material from ambient air temperature to a maximum of 160EF. Some lines and markings may be applied with a brush or small hand-propelled machine designed for the purpose, if approved.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Do not apply paint to concrete surfaces until concrete has cured for 28 days.

3.2 PREPARATION

A. All dirt, oil, grease, excess pavement marking material, loose or other foreign material shall be removed to clean and prepare the pavement to receive the pavement marking. Removal shall be accomplished by brooming, sandblasting, waterblasting, compressed air, or other approved mechanical means. Grooving or grinding will not be permitted. The surface shall be thoroughly dry. Paint shall be applied when the pavement temperature is 40°F or above.

3.3 EXISTING WORK

A. Remove existing markings in an acceptable manner. Do not remove existing pavement markings by painting over with blank paint. Remove by methods that will cause least damage to pavement structure or pavement surface. Satisfactorily repair any pavement or surface damage caused by removal methods.

3.4 APPLICATION

A. Parking lot stall markings shall be continuous white non-reflectorized stripes, 4" in width. They shall be clearly and sharply delineated, straight and true and tangent. Segments shall be square at each end without mist, drip, or spatter. The wet film thickness of paint shall be a minimum of 0.015 inch.

3.5 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution Requirements: Requirements for protecting finished Work.

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B. Protect painted pavement markings from vehicular and pedestrian traffic until paint is dry and track free. Follow manufacturer's recommendations or use minimum of 30 minutes. Consider barrier cones as satisfactory protection for materials requiring more than 2 minutes dry time.

END OF SECTION

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SECTION 32 31 00

SLIDING GATES OPERATOR

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electric gate operators.

B. Sensors and controls.

1.2 RELATED SECTIONS

A. Section 32 31 13 – Fences and Gates: Adjoining fences and gates.

B. Section 03 30 00 – Cast-in-Place Concrete: Concrete mounting pads.

C. Division 16 – Requirements for electrical connections.

1.3 REFERENCES

A. Underwriters Laboratories (UL): UL 325 – Standard for Safety for Door, Drapery, Gate, Louver, and Window Operators and Systems.

B. Underwriters Laboratories (UL): UL 991 – Standard for Tests for Safety Related Controls Employing Solid-State Devices.

C. American Society Testing Materials (ASTM): ASTM F2200 – Standard Specification for Automated Vehicular Gate Construction.

D. National Electrical Manufacturers Association (NEMA): NEMA ICS 6 – Industrial Control Systems: Enclosures.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 30 00 – Administrative Requirements.

B. Product Data: Manufacturers data sheets on each product to be used, including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements.
   3. Installation methods.

C. Shop Drawings: Submit shop drawings showing layout, profiles, and product components, including anchorage, edge connections, and accessories.
   1. Operation, installation, and maintenance manuals including wire diagrams.
   2. Risers, layouts, and special wiring diagrams showing any changes to standard drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials and products in strict compliance with manufacturer’s instructions and industry standards.

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B. Store products indoors in manufacturer's original containers and packaging with labels clearly identifying product name and manufacturer. Protect from damage.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Substantial transformation and final assembly shall occur in the United States of America per Section 1605 of the ARRA-09.

B. Installer Qualifications: Installation performed by factory authorized dealer contractor specifically trained in gate operator systems of the type found within this section.
   1. Provide documentation of maintenance and repair service availability for emergency conditions.
   2. Provide quarterly maintenance for one year following Substantial Completion of the Project.

1.7 WARRANTY

A. Manufacturers standard five (5) year warranty.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer: DoorKing, Inc.; 120 S. Glasgow Ave; Inglewood, CA 90301; Toll-Free Tel: 800-826-7493; Tel: 310-645-0023; Fax: 310-641-1586; Email: ghendrix@doorking.com; Web: doorking.com.

B. Basis of Design: Doorking Model 9150

C. Requests for substitutions will be considered in accordance with provisions of Section 01 60 00 – Product Requirements.

2.2 SLIDING GATE OPERATORS

A. Microprocessor based solid-state control board interacting with card readers, RF transmitters, access control systems, ticket machines, other activating devices as required, external devices (photo-eyes, contact edges) for entrapment protection and vehicle (loop) sensing systems. Control board shall include built-in close timer (1-25 seconds), built-in ports for two (2) plug-in loop detectors, partial open input, programming switches to set various operating modes, inherent magnetic pulse obstruction sensing reverse system. System shall employ Fail-Safe operation upon primary (AC) power outage.
   1. Compliance: Compliant to UL 325, UL 991 and CSA C22.2 No. 247 and listed by Intertek Testing Laboratories NA, Inc. (ETL), a Nationally Recognized Testing Laboratory.
      a. This model is intended for use in Class I, II, III and IV vehicular slide gate applications.
   2. Warranty: Five (5) year manufacturer's standard warranty.
   3. Maximum Gate Length:
      a. 45-feet with 1 HP motor.
   4. Maximum Gate Weight:

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a. 1,500 Lbs. with 1 HP motor.

5. Operator speed: approximately 11-inches per second.
6. Enclosure:
   a. 12 gage, 0.108 inch (2.6 mm) G90 hot-dipped galvanized steel, finished with polyester powdercoat, exterior grade semi-gloss texture gray.
7. Configuration: Left or right hand mount; front, center or rear mounting configurations.
8. Mounting: Pad or post mount.
9. Electrical Power Requirements: 460 VAC.
   a. 460 VAC requires DoorKing High Voltage Kit.
10. Motor: Continuous Duty Motor.
    a. 1 HP
11. Dead Bolt Lock: Solenoid dead bolt engages if an attempt is made to force the gate open.
12. Fail-Safe Operation: Upon loss of primary (AC) power, system shall automatically be transferred to a fail-safe mode allowing the gate to be pushed open without the use of special knowledge, keys or other releasing mechanisms.
13. Primary Reduction: Adjustable clutch, single cog belt drive train.
14. Pulling Medium: #40 roller chain
15. Magnetic Limit Switches: Automatic setting with no mechanical switches to set, wear out or break.
16. Operating Switches: Built-in power (on-off), reset and operating switches.
17. Convenience Outlets: Two (2) 115 VAC for accessory transformers.
18. Entrapment Protection
    a. Photo-electric eye (non-contact sensor).
19. Accessories: Provide the optional accessories listed below.
    a. Traffic signal (red / green).
    b. Thermostatically controlled heater kit.
    c. Base Plate – for post mount applications.
    d. Chain tray kit – to support roller chain on long gates.
    e. Fail-Secure Lock Kit – requires a key lock to open the gate upon primary (AC) power loss.
    f. Plug-in loop detectors.
    g. Photo-electric beams – reverses direction of gate if the light beam is obstructed.
    h. Gate Tracker Expansion – provides time and date stamped electronic record of cycles, input errors, loop detector input errors, obstruction hits and power cycles.
       1) Requires companion DoorKing 1830 Series access controller.
    i. Backup power inverter – allows system to remain operation upon loss of primary (AC) power.

PART 3 - EXECUTION

3.1 INSTALLATION

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A. It is preferred but not required, that this product be installed by a qualified technician who is certified by either the Accreditation and Certification Institute (ACI) or the Institute of Door Dealer Education and Accreditation (IDEA).
B. Equipment shall be mounted, firmly secured, plumb and level, as required.
C. Wiring shall be uniform and in accordance with national electric codes and manufacturer's instructions.
D. All splices shall be in easily accessible junction boxes or on terminal boards.
E. All cable runs in all junction boxes shall be tagged and identified.
F. Coordinate all work with other effected trades and contractors.

3.2 SYSTEM INITIALIZING AND PROGRAMMING

A. System shall be turned on and adjustment made to meet requirements of specifications and on-site conditions.
B. System shall function as specified.

3.3 SYSTEM TEST PROCEDURES

A. System shall be completely tested to assure that all components and accessories are hooked-up and in working order.
B. System shall be pre-tested by contractor and certified to function in accordance with plans and specifications.
C. System shall be tested in presence of owner's representative.

3.4 OWNER INSTRUCTIONS

A. Installation contractor shall conduct up to (1) hour of instruction in use and operation of the system to designated owner representatives, within (30) days of acceptance.
B. Installation contractor shall conduct up to (1) hour of technical training, in troubleshooting and service of the system, to designated owner representatives within (90) days of system acceptance.

3.5 MANUALS AND DRAWINGS

A. Contractor shall provide owner with (2) copies of standard factory prepared operation, installation and maintenance manuals. Manuals shall include typical wiring diagrams.
B. Contractor shall provide owner with (2) copies of any risers, layouts, and special wiring diagrams showing any changes to standard drawings, if required on project.

3.6 MAINTENANCE

A. The manufacturer recommends periodic maintenance at one (1), three (3) and 12 month intervals as described in the installation and maintenance manual.
B. External reversing devices should be checked at least once a month.

END OF SECTION

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SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing and installing galvanized steel chain link fencing and gates.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 31 00 - Cast-in-Place Concrete
2. Section 05 05 13 - Galvanizing
3. Section 08 71 00 - Finish Hardware
4. Section 09 96 00 - High Performance Coatings

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM F 669 - Specification for Strength Requirements of Metal Posts and Rails for Industrial Chain Link Fence
2. ASTM F 1083 - Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
3. ASTM F 1234 - Protective Coatings on Steel Framework for Fences
4. ASME B36.10M - Welded and seamless wrought steel pipe
5. FS RR-F-191 - Fencing, Wire and Post, Metal

1.3 DESIGN

A. General: Provide fencing of the chain-link type eight feet high with seven feet of diamond mesh woven wire fabric topped by extension arms with a vertical height of approximately one foot above the top of the fabric. Design the extension arms slanted out at an angle of 45 degrees and provide the arms to carry three double strands of barbed wire. Locate the fence as shown.

B. Fabric, Supports and Fittings: Provide steel fabric, supports and fittings except as specified.

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C. Pipe Sizes and Weights: Provide pipe sizes and weights meeting the requirements of ASME B 36.10, Table 2 and ASTM A 53, Table 1. All pipe sizes listed are nominal, unless otherwise indicated.

PART 2 PRODUCTS

2.1 FABRIC

Provide fabric that is a one piece woven 2-inch mesh chain link of 6-gauge steel wire with a minimum break load of 2170 lbs/ft. and which is interwoven to form a continuous fabric with no splices and is hot-dip galvanized after weaving. Provide the top selvage knuckled for fabric 60 inches high and under, and the bottom selvage twisted and barbed for fabric over 60 inches high. Clean the fabric of all grease and foreign matter before shipping. Stretch the fabric tightly approximately two inches above grade level and attach the fabric to the terminal or gate posts using beveled tension bands and tension bars.

2.2 TENSION WIRE

A. For the tension wire for the fence bottom use minimum 6-gauge galvanized coil spring steel.

2.3 TOP AND BRACE RAILS

A. General: Furnish the top rail in approximately 20-foot lengths with couplings approximately 6 inches long for each joint. Provide one coupling in each 5 with an expansion spring. Provide the rail continuous from end-to-end for each run of fence. Provide brace rails at all terminal posts, locate the rails midway between the top and bottom of the fabric and extend from the terminal post to the first adjacent line post. Securely fasten rails at both ends. Provide top and brace rails that are galvanized steel.

B. Pipe Type: For galvanized steel top and brace rails, use 1-1/4-inch, Schedule 40 pipe or a 1.625- by 1.25-inch roll-formed section with minimum bending strength of 192 pounds on 10-foot span.

2.4 POSTS

A. General: Provide all posts that are galvanized steel pipe or roll-formed section.

B. Pipe Posts: Provide pipe posts as follows:

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1. For end, corner and pull posts use 2-1/2-inch, Schedule 40 pipe

2. For line posts use 2-inch, Schedule 40 pipe

3. For gate posts use the following pipes for different leaves:

    a. For leaves up to 6 feet wide, use 2-1/2-inch Schedule 40 pipe

    b. For leaves over 6 feet to 12 feet wide, use 3-1/2-inch Schedule 40 pipe

    c. For leaves over 12 feet to 18 feet wide, use 6-inch Schedule 40 pipe

C. Bending Strength: Provide materials with the minimum bending strength based on a 6-foot cantilever for rolled formed or tube posts as follows:

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	Minimum Bending Strength (lbs)
	Galvanized Steel
1. End, Corner and Pull Posts:	
2.875" O.D. roll formed or	444
2-1/2-inch square tube	547
2. Line Posts:	
For fences 8 feet maximum height 1.875- by 1.625-inch C-Section	245
For fences over 8 feet high 2.25- by 1.703-inch C-Section	347
3. Gate Posts:	
For leaves up to 6 feet wide (2.875-inch O.D. roll formed or	444
2-1/2-inch square tube	645

2.5 GATES

A. General: For the perimeter construction of gates with leaves up to 6 feet wide, use 1-1/2-inch Schedule 40 pipe or 1-1/2-inch square steel tube, and for gates with leaves greater than 6 feet wide, use 2-inch Schedule 40 pipe or 2-inch square steel tube.

B. Braces: Provide the gates with sufficient horizontal and vertical members and bracing to ensure structural stability to prevent sagging and to provide for the attachment of fabric, hardware and accessories. Provide gates with diagonal cross

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bracing consisting of 3/8-inch diameter adjustable length truss rods where necessary to provide frame rigidity without sag or twist.

C. Cantilever Sliding Gates: Furnish cantilever overhang as follows:

Gate Leaf Size	Overhang
6'-0" to 10'-0"	6'-6"
11'-0" to 14'-0"	7'-6"
15'-0" to 22'-0"	10'-0"
12'-0" to 30'-0"	12'-0"

1. For gates leaf sizes 23'-0" to 30'-0", add one additional 2-inch square lateral support rail welded adjacent to the top horizontal rail. Make the bottom rail of 2" x 4" tubing weighing 1.71 pounds per foot.

2. Provide all cantilever overhang frames having 3/8-inch galvanized steel brace rods.

3. Provide the enclosed track made of a combined track and rail aluminum extrusion having a total weight of 3.72 pounds per foot and designed to withstand a reaction load of 2,000 pounds.

4. Provide each gate leaf with two swivel type zinc die cast trucks having four sealed lubricant ball-bearing wheels, 2-inch in diameter by 9/16-inch in width, with two side rolling wheels to insure alignment of the truck in the track. Hold trucks to post brackets by 7/8-inch diameter ball bolts with 1/2-inch shank. Design truck assemblies to take the same reaction load as the track.

5. Install gates on 4-inch OD Schedule 40 galvanized posts weighing 9.1 pounds per foot. Use three posts for single slide gate and four posts for double slide gate.

6. Provide guide wheel assemblies for each supporting post. Provide each assembly consisting of two rubber wheels 4 inches in diameter attached to a post so that the bottom horizontal member will roll between the wheels which can be adjusted to maintain gate frames plumb and in proper alignment.

D. Gate Accessories: Equip gates with hinges, latches, center stops, hasps, holdbacks, and padlocks. Provide hinges, latches, center stops, hasps, and holdbacks that are cast iron, malleable iron, or pressed steel hot-dip galvanized after fabrication. Provide double gates with a center drop bar and gate holdbacks.

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E. Latches: Provide gate latches that are positive locking, pivoting type with the padlocking arrangement accessible from either side of the gate.

F. Padlocks: Provide padlocks as specified in Section 08 71 00.

G. Hinges: Hang all gates on offset hinges to permit swinging the gate through a 180-degree arc to lie, when not obstructed, along and parallel to the line of the fence.

2.6 ATTACHMENTS

A. General: Provide all attachments fabricated of galvanized carbon steel.

B. Tension Bars: Provide 3/16-inch by 3/4-inch galvanized carbon steel tension bars attached to the terminal posts by means of beveled edge bands.

C. Truss Rods: Provide 3/8-inch diameter galvanized carbon steel truss rods. Securely mount truss rods between the line post end of the brace rail and the base of the terminal post.

D. Post Tops: Provide post tops of galvanized pressed steel or malleable iron to form weathertight caps for post or tube post. Make provisions for installation or passage of the top rail.

E. Brace and Tension Bands: Provide galvanized steel brace bands and tension bands, of the "unclimbable" beveled edge type with 3/8-inch diameter square shouldered aluminum carriage bolts, nonremovable from outside of the fence.

F. Rail Couplings: Provide rail couplings of the outside sleeve type, not less than six inches long, self-centering, which allows for expansion and contraction. Provide galvanized steel rail couplings.

G. Fabric Ties: Provide 11-gauge galvanized steel fabric ties.

H. Hog Rings: Provide 11-gauge wire, aluminum alloy, Type 6061-T6 hog rings.

I. Extension Arms: Provide galvanized pressed steel extension arms for supporting the barbed wire. Design the arms with an adequate cross section to withstand without failure or permanent deflection a perpendicular force of 250 pounds applied at the end of the arm when the arm is securely attached to the post. Construct extension arms to be slanted out.

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PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install all fencing and accessories according to the manufacturer's recommendations. Do not begin installation and erection before final grading is completed, unless otherwise approved.

B. Excavation: Drill or hand excavate (using post hole digger) holes for posts to the diameter and spacing indicated, in firm, undisturbed or compacted soil.

1. If not indicated, excavate holes for each post to the minimum diameter recommended by the fence manufacturer, but not less than four times the largest cross-section of the post.

2. Unless otherwise indicated excavate the hole depths approximately 3 inches lower than the post bottom, with the bottom of posts set not less than 36 inches below the finished grade surface.

C. Tension Wire: Attach the tension wire to the bottom of the fabric by hog rings spaced at 24-inch intervals and to terminal posts by brace bands.

D. Posts: Set posts plumb in concrete encasement at not more than 10-foot centers in the line of the fence with the tops properly aligned. Extend concrete encasement for line posts a minimum of three feet below finish grade with a minimum diameter of ten inches. Extend concrete encasement for terminal, corner and gate posts 40 inches below finished grade, except gate posts for leaves greater than 6 feet, for which extend the encasement 54 inches below grade. Provide the minimum diameter of encasement for terminal, corner and gate posts to be sufficient to provide not less than four inches between any part of the post and the face of the concrete and in no case provide the diameter to be less than 12 inches. Set line posts 32 inches into the concrete and set all other posts 36 inches, except gate posts for leaves greater than 6 feet wide, which are to be set 48 inches into the concrete. Slope the top exposed surface of the concrete to shed water and provide a neat appearance.

1. Place concrete around posts and vibrate or tamp for consolidation. Check each post for vertical and top alignment and hold posts in position during placement and finishing operations.

   a. Unless otherwise indicated, extend the concrete footing 2 inches above grade and trowel to a crown to shed water.

2. Where aluminum is in contact with concrete, coat the aluminum as specified in Section 09 96 00.

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E. Fabric Ties: Space fabric ties approximately 14 inches apart on the line posts and 24 inches apart on the rails. (For clips used with C-section posts, use galvanized 11-gauge steel wire.)

F. Fabric: Leave approximately 2 inches between finished grade and the bottom selvage, unless otherwise indicated. Pull the fabric taut and tie to posts, rails, and tension wires. Install the fabric on the security side of the fence and anchor the fabric to the framework so that the fabric remains in tension after the pulling force is released.

G. Fasteners: Install nuts for tensions bands and hardware bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent nut removal.

END OF SECTION

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SECTION 32 91 19

LANDSCAPE GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Final grade topsoil for finish landscaping.

1.2 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittal procedures

B. Materials Source: Submit name of imported materials source.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.3 QUALITY ASSURANCE

A. Furnish each topsoil material from single source throughout the Work.

B. Perform Work in accordance with local standards.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Topsoil: As specified in Section 31 20 00. Some topsoil is provided on site. Supplement as needed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify building and trench backfilling have been inspected.

C. Verify substrate base has been contoured and compacted.

3.2 PREPARATION

A. Protect landscaping and other features remaining as final Work.

B. Protect existing structures, fences, sidewalks, utilities, paving, and curbs.

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3.3 SUBSTRATE PREPARATION

A. Eliminate uneven areas and low spots.

B. Remove debris, roots, branches, stones, in excess of 1/2 inch in size. Remove contaminated subsoil.

C. Scarify surface to depth of 3 inches where topsoil is scheduled. Scarify in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

3.4 PLACING TOPSOIL

A. Place topsoil in areas where seeding is required to thickness as scheduled. Place topsoil during dry weather.

B. Fine grade topsoil to eliminate rough or low areas. Maintain profiles and contour of subgrade.

C. Remove roots, weeds, rocks, and foreign material while spreading.

D. Manually spread topsoil close to plant material, building, and other structures to prevent damage.

E. Roll placed topsoil.

F. Remove surplus subsoil and topsoil from site.

G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.5 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Tolerances.

B. Top of Topsoil: Plus or minus 1/2 inch.

3.6 PROTECTION OF INSTALLED WORK

A. Section 01 70 00 - Execution Requirements: Requirements for protecting finished Work.

B. Prohibit construction traffic over topsoil.

3.7 SCHEDULES

A. Compacted topsoil thicknesses:
   1. Seeded Grass: 6 inches.
   2. Landscape Beds adjacent to lawns: 6 inches.
   3. Landscape Beds bordered on all sides with pavement: 18 inches.

END OF SECTION

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SECTION 32 92 19

SEEDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fertilizing.
   2. Seeding.
   3. Hydroseeding.
   4. Mulching.
   5. Maintenance.

1.2 DEFINITIONS

A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution Requirements: Requirements for submittals.

B. Operation and Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer.

1.5 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.

B. Perform Work in accordance with local standards.

1.6 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition.

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B. Provide certificate of compliance from authority having jurisdiction indicating approval of seed mixture.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.

B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Seeding Season: March 15 - June 15 and August 15 - October 15.

B. Do not sow immediately following rain, when ground is frozen or too dry, during windy periods, or when the temperature will be above 85 degrees during the germination period.

1.9 MAINTENANCE SERVICE

A. Section 01 70 00 - Execution Requirements: Requirements for maintenance service.

B. Maintain seeded areas immediately after placement for not less than 60 days after substantial completion and longer as required to establish an acceptable lawn. If seeded in fall and not given full 60 days of maintenance, or if not considered acceptable at that time, continue maintenance the following spring until acceptable lawn is established.

PART 2 - PRODUCTS

2.1 SEED MIXTURE

A. Suppliers:
1. Stock Seed Farms; Murdock, Nebraska..
2. Wildlife Nurseries; Oshkosh, Wisconsin.
3. Applewood Seed Company; Arvada, Colorado.
4. Substitutions: Section 01 60 00 - Product Requirements.

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B. Seed Mixture:

"TALL FESCUE SLOPE MIX"

PROPORTION BY WEIGHT	COMMON NAME	BOTANICAL NAME	MIN. % GERM.	MIN. % PURE SEED	MAX. % WEED SEED
PERMANENT MATRIX					
35 %	Tall Fescue	Festuca elatior (var. arundinacea) (equal amounts of 'Kentucky 31' & 'Alta')	85	98	0.30
21 %	Perenn. Ryegrass	Lolium perenne (equal amounts of 'Fiesta II' &'Manhattan II')	90	97	0.30
14 %	Creeping Red Fescue	Festuca rubra var.	90	98	0.30
TEMPORARY MATRIX					
23 %	Seed Oats	Avina sativa	-	-	0.50
7 %	Annual Ryegrass	Lolium multiflorum	90	95	0.50

C. Sowing Rate
1. Sow grass seed at the following rates:
   a. Sow Mixture 5 lbs/1,000 sq. ft.
2. The following formula shall be used to determine the amount of commercial seed required to provide in each kind of seed the specified quantities of pure live seed.
   a. Live Seed x Purity x Germination =Pounds Commercial Seeds Required

2.2 SOIL AMENDMENTS

A. Topsoil: Excavated from site and free of weeds.

B. Topsoil: Must be supplemented as required. Provide a fertile, friable, natural loam, surface soil obtained from local sources (do not obtain from bogs or marshes), capable

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of sustaining vigorous plant growth; free of subsoil, clay or impurities, plants, weeds and roots; pH value of minimum 5.5 and maximum 7.5.

C. Lime: Natural dolomitic limestone containing not less than 85% of total carbonates with a minimum of 30% magnesium carbonates, ground so that not less than 90% passes a 10-mesh sieve and not less than 50% passes a 100-mesh sieve.

D. Aluminum Sulfate: Commercial grade.

E. Commercial Fertilizer: Complete fertilizer of neutral character, with some elements derived from organic sources. Provide slow release fertilizer with percentage of nitrogen required to provide not less than 4 lb. of actual nitrogen, 1 lb. of phosphorus and 2 lb. of potash per 1000 square feet of lawn area.

F. Superphosphate: Soluble mixture of treated minerals; 20% available phosphoric acid. For lawns, provide high phosphorus fertilizer to supplement complete fertilizer as required pending topsoil analysis. Desired total of phosphorus required: 3.6 lb. of actual phosphorus per 1000 square feet of lawn area.

2.3 ACCESSORIES

A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.

B. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.

C. Erosion Fabric: Jute matting, open weave.

D. Herbicide: Systematic weed control: "Tupersan" or equal.

E. Stakes: Softwood lumber, chisel pointed.

F. String: Inorganic fiber.

2.4 SOURCE QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Testing, inspection and analysis requirements.

B. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.

C. Provide recommendation for fertilizer and lime application rates for specified seed mix as result of testing.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify that prepared soil base has been set at finish grade and is ready to receive the work of this Section. (Finish grade will be set □ 1/10' (1.2") from final grade. See Section 32 91 19.).

C. Determine location of underground utilities and perform work in a manner, which will avoid possible damage. Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.

D. When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Architect before seeding.

E. Preparation of Unchanged Grades: Where seeding areas that have not been disturbed by excavating operations, prepare soil* for seeding as follows: Apply 3 inches of topsoil and soil amendments as specified; till to a depth of approximately 6 inches; remove high areas and fill in depressions; till soil to a homogenous mixture of fine texture, free of clods, stones, roots and other extraneous matter.

*Prior to preparation of unchanged areas, remove existing vegetation. Dispose of such material outside of Owner's property; do not turn over into soil being prepared for lawns. If a herbicide is used, delay seeding as required to ensure proper germination.

3.2 ADDITION OF TOPSOIL AND OTHER SOIL AMENDMENTS

A. Spread topsoil as required to meet final grade. Place topsoil during dry weather and on dry unfrozen subgrade. Remove vegetable matter and foreign non-organic material from topsoil while spreading.

B. Apply fertilizer in accordance with manufacturer's instructions with any topsoil required to meet final grade. Do not apply fertilizer at same time or with same machine as will be used to apply seed.

C. Add fertilizer at rates of 25 lbs. (slow-release 16-4-8) per 1000 square feet and 13 lbs. (0-20-0) per 1000 square feet. Rates may vary based on topsoil analysis.

D. If required, add lime or aluminum sulfate to bring soil mix to the pH range specified. Mixing shall be done in a thorough manner to ensure uniform distribution of materials throughout, by tilling or other approved method.
   1. Limestone: When the pH value is below the specified level, add ground limestone at the rate required to raise the pH.
   2. Aluminum sulfate or wettable sulfur: When pH value is above specified level, add aluminum sulfate or wettable sulfur at the rate required to lower the pH.

E. Coordinate the removal of any remaining stockpiled topsoil with appropriate party.

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3.3 FINAL PREPARATION OF SOIL

A. After topsoil and other soil amendments have been spread as required, thoroughly till into top 3 inches of subgrade. Meet lines, grades and elevations as shown on plans, after light rolling and natural settlement. (After tilling in amendments, wet the soil thoroughly to settle it and allow it to dry before final grading.)

B. Grade to smooth, even surface with loose, uniformly fine texture. Roll, rake and drag lawn areas, remove ridges and fill depressions until smooth. Ensure positive drainage and blend slopes into level areas. Limit final grading to areas that can be seeded immediately after grading.

C. Restore lawn areas to specified condition if eroded or otherwise disturbed after final grading and prior to seeding.

3.4 TOLERANCES

A. Top of Final Grade: Plus or minus 1/2 inch from final grade.

3.5 SEEDING

A. Apply seed using a spreader or seeding machine evenly in two intersecting directions. Rake in lightly.

B. Do not seed areas in excess of that which can be mulched on same day.

C. Immediately following seeding, apply a straw mulch uniformly in a continuous blanket at the rate of 2-1/2 tons per acre, or 2 - 50 lb. bales per 1000 sq. ft. of area. A mechanical blower may be used for straw mulch application. Maintain clear of shrubs and trees.

D. Apply water with a fine spray immediately after mulching. Saturate to 4 inches of soil.

3.6 HYDROSEEDING

A. Apply seeded slurry with a hydraulic seeder/mulcher at a rate per seeding schedule and a tackifier (60 gals/acre) and wood cellulose fiber mulch (2000 lbs/acre) evenly in two intersecting directions.

B. Apply water with a fine spray immediately after each area has been hydroseeded/mulched. Saturate to 6-8 inches of soil.

3.7 SEED PROTECTION

A. Identify seeded areas with stakes and string around area periphery as needed to discourage foot traffic. Remove once grass is established.

B. Cover seeded slopes where grade is 4 inches per foot or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.

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C. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.

D. Secure outside edges and overlaps at 36 inch intervals with stakes.

E. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.

F. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.8 MAINTENANCE

A. Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regrading and replanting for not less than 60 days after substantial completion and longer as required to establish a smooth, acceptable lawn, free of eroded or bare areas.

B. Watering: Keep soil moist during seed germination period, requiring at least daily watering. First week after germination, soak ground every other day. Thereafter, supplement rainfall to produce total of 1 inch per week after germination until the end of the maintenance period.

C. Mowing: Mow twice. When grass reaches 2-1/2 in. in height, mow to 1-3/4 in. height. Remove grass clippings. Thereafter, Owner to be responsible for mowing maintenance.

D. Control growth of weeds. Apply herbicides, if required, in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.

E. Reseed and mulch spots larger than 1 sq. ft. not having uniform stand. A stand of turf is defined as 95 percent ground cover.

F. Protect seeded areas with warning signs during maintenance period. Remove all barriers and signs at end of maintenance period.

3.9 ACCEPTANCE

A. Seeded areas will be inspected at completion of maintenance period and accepted subject to compliance of installation and maintenance requirements.

END OF SECTION

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SECTION 33 05 13

MANHOLES AND STRUCTURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Monolithic concrete manholes with transition to cover frame, covers, anchorage, and accessories.
2. Modular precast concrete manhole with tongue-and-groove joints, covers, anchorage, and accessories.
3. Monolithic FRP manholes with transition to cover frame, covers, anchorage, and accessories.
4. Masonry manholes with masonry transition to cover frame, covers, anchorage, and accessories.
5. Bedding and cover materials.

1.2 REFERENCES

A. American Concrete Institute:
1. ACI 318 - Building Code Requirements for Structural Concrete.
2. ACI 530/530.1 - Building Code Requirements for Masonry Structures and Specifications for Masonry Structures.

B. ASTM International:
1. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. ASTM C55 - Standard Specification for Concrete Brick.
4. ASTM C62 - Standard Specification for Building Brick (Solid Masonry Units Made From Clay or Shale).
5. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
6. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
7. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.
8. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals.
9. ASTM D3753 - Standard Specification for Glass-Fiber-Reinforced Polyester Manholes and Wetwells.

1.3 DESIGN REQUIREMENTS

A. Equivalent strength: Based on structural design of reinforced concrete as outlined in ACI 318.

B. Design of Lifting Devices for Precast Components: In accordance with ASTM C913.

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C. Design of Joints for Precast Components: In accordance with ASTM C913; maximum leakage of 0.025 gallons per hour per foot of joint at 3 feet of head.

1.4 SUBMITTALS

A. None required.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.

1.6 DELIVERY, STORAGE AND HANDLING

A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.

B. Comply with precast concrete manufacturer's instructions for unloading, storing and moving precast manholes.

C. Store precast concrete manholes to prevent damage to Owner's property or other public or private property. Repair property damaged from materials storage.

D. Mark each precast structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers shown on Drawings to indicate its intended use.

PART 2 PRODUCTS

2.1 MANHOLES

1. Structures per INDOT Standards

B. Manhole Sections: Reinforced precast concrete in accordance with ASTM C478 with gaskets in accordance with ASTM C923.

2.2 FRAMES AND COVERS

A. Manufacturers:
1. As noted on drawings or equal.

2. Substitutions: Section 01 60 00 - Product Requirements.

2.3 COMPONENTS

A. Manhole Steps: Formed FRP rungs; 3/4 inch diameter. Formed integral with manhole sections.

B. Base Pad: Cast-in-place concrete of type specified in Section 03 30 00 leveled top surfaces.

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2.4 CONFIGURATION

A. Shaft Construction: Concentric with eccentric cone top section; lipped male/female dry joints; sleeved to receive pipe sections.

B. Shape: Cylindrical.

C. Clear Inside Dimensions: As required.

D. Design Depth: As indicated on Drawings.

E. Clear Cover Opening: As indicated on Drawings.

F. Pipe Entry: Furnish openings as indicated on Drawings.

G. Steps: 12 inches wide, 16 inches on center vertically, set into manhole wall.

2.5 BEDDING AND COVER MATERIALS

A. Bedding: As shown on drawings.

2.6 FINISHING - STEEL

A. Galvanizing: ASTM A123/A123M; hot dip galvanize after fabrication.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify items provided by other sections of Work are properly sized and located.

C. Verify built-in items are in proper location, and ready for roughing into Work.

D. Verify correct size of manhole excavation.

3.2 PREPARATION

A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.

B. Do not install structures where site conditions induce loads exceeding structural capacity of structures.

C. Inspect precast concrete structures immediately prior to placement in excavation to verify structures are internally clean and free from damage. Remove and replace damaged units.

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3.3 INSTALLATION

A. Excavation and Backfill:
   1. Excavate for manholes in accordance with Section 31 23 16 in location and to depth shown. Provide clearance around sidewalls of structure for construction operations.
   2. When groundwater is encountered, prevent accumulation of water in excavations. Place manholes in dry trench.
   3. Where possibility exists of watertight structure becoming buoyant in flooded excavation, anchor structure to avoid flotation.

B. Place base pad, trowel top surface level.

C. Place manhole sections plumb and level, trim to correct elevations, anchor to base pad.

D. Backfill excavations for manholes in accordance with Section 31 23 16.

E. Form and place manhole cylinder plumb and level, to correct dimensions and elevations.

F. Cut and fit for pipe.

G. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour to form continuous drainage channel as indicated on Drawings.

H. Set cover frames and covers level without tipping, to correct elevations.

I. Coordinate with other sections of Work to provide correct size, shape, and location.

3.4 PRECAST CONCRETE MANHOLE INSTALLATION

A. Lift precast components at lifting points designated by manufacturer.

B. When lowering manholes into excavations and joining pipe to units, take precautions to ensure interior of pipeline and structure remains clean.

C. Set precast structures bearing firmly and fully on crushed stone bedding, compacted in accordance with provisions of Section 31 23 16 or on other support system shown on Drawings.

D. Assemble multi-section structures by lowering each section into excavation. Lower, set level, and firmly position base section before placing additional sections.

E. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.

F. Joint sealing materials may be installed on site or at manufacturer’s plant.

G. Verify manholes installed satisfy required alignment and grade.

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H. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe. Fill annular space with mortar.

I. Cut pipe to finish flush with interior of structure.

J. Shape inverts through manhole as shown on Drawings.

3.5 CAST-IN-PLACE CONCRETE MANHOLE INSTALLATION

A. Prepare crushed stone bedding or other support system shown on Drawings, to receive base slab as specified for precast structures.

B. Erect and brace forms against movement in accordance with Section 03 10 00.

C. Install reinforcing steel as indicated on Drawings and in accordance with Section 03 20 00.

D. Place and cure concrete in accordance with Section 03 30 00.

3.6 FRAME AND COVER INSTALLATION

A. Set frames using mortar and masonry. Install radially laid concrete brick with 1/4 inch thick vertical joints at inside perimeter. Lay concrete brick in full bed of mortar and completely fill joints. Where more than one course of concrete brick is required, stagger vertical joints.

B. Set frame and cover 2 inches above finished grade for manholes with covers located within unpaved areas to allow area to be graded away from cover beginning 1 inch below top surface of frame.

3.7 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Test concrete manhole and structure sections in accordance with ASTM C497.

C. Test cast-in-place concrete in accordance with Section 03 30 00.

D. Vertical Adjustment of Existing Manholes:
   1. Where required, adjust top elevation of existing manholes to finished grades shown on Drawings.
   2. Reset existing frames, grates and covers, carefully removed, cleaned of mortar fragments, to required elevation in accordance with requirements specified for installation of castings.
   3. Remove concrete without damaging existing vertical reinforcing bars when removal of existing concrete wall is required. Clean vertical bars of concrete and bend into new concrete top slab or splice to required vertical reinforcement, as indicated Drawings.
   4. Clean and apply sand-cement bonding compound on existing concrete surfaces to receive cast-in-place concrete in accordance with Section 03 30 00.

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END OF SECTION

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SECTION 33 05 23.13

UTILITY HORIZONTAL DIRECTIONAL DRILLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavation for approach trenches and pits.
2. Horizontal directional drilling.
3. Pipe.
4. Drilling fluid system.

B. Related Requirements:

1. Section 03 60 00 - Grouting: Filling of abandoned boreholes.
2. Section 31 05 13 - Soils for Earthwork: Subsoil fill as required by this Section.
3. Section 31 23 16 - Excavation: Excavation of subsoil and excavation supports as required by this Section.
4. Section 31 23 17 - Trenching: Trenching as required by this Section.
5. Section 33 11 13 - Public Water Utility Distribution Piping: Water distribution pipe testing requirements of this Section.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials:

1. AASHTO T 180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:

1. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3).
2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3).
3. ASTM D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

4. ASTM D3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.

5. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

6. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

7. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

8. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

9. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.

10. ASTM F1962 - Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings.

C. American Water Works Association:

1. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

2. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution.

3. AWWA C901 - Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13 mm) Through 3 In. (76 mm), for Water Service.

4. AWWA C906 - Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) Through 63 In. (1,600 mm), for Water Distribution and Transmission.

D. National Utility Contractors Association:

1. NUCA - Horizontal Directional Drilling Good Practices Guidelines.

E. Plastics Pipe Institute:

1. PPI TR-46 - Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe.

1.3 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Requirements for coordination.

B. Coordinate Work of this Section with Vermillion Rise Mega Park, INDOT (when applicable) and Vermillion County Jail Addition & Renovation General Contractor.

1.4 PREINSTALLATION MEETINGS

A. Section 01 30 00 - Administrative Requirements: Requirements for preinstallation meeting.

1.5 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data:

1. Identify source of water used for drilling.

2. Submit copy of approvals and permits for use of water source.

C. Shop Drawings:

1. Submit technical data for equipment, method of installation, and proposed sequence of construction.

2. Include information pertaining to pits, dewatering, method of spoils removal, and equipment size, capacity, and capabilities, including installing pipe on radius, type of drill bit, drilling fluid, method of monitoring line and grade, detection of surface movement, name plate data for drilling equipment, and mobile spoils removal unit.

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

F. Qualifications Statement:

1. Submit qualifications for driller.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.

B. Project Record Documents: Record actual locations of pipe and invert elevations.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

D. Record actual depth of pipe at 25-foot intervals.

E. Record actual horizontal location of installed pipe.

F. Show depth and location of abandoned bores.

G. Record depth and location of drill bits and drill stems not removed from bore.

1.7 QUALITY ASSURANCE

A. Perform Work according to following:

1. NUCA HDD Good Practices Guidelines.

2. ASTM F1962.

3. PPI TR-46.

B. Perform Work according to INDOT, Clinton County and the City of Frankfort standards.

1.8 QUALIFICATIONS

A. Driller: Company specializing in performing Work of this Section with minimum five years' documented experience in construction of work of a similar nature.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Provide temporary end caps and closures on piping and fittings until pipe is installed.

C. Protect pipe from entry of foreign materials and water by installing temporary covers, completing sections of Work, and isolating parts of completed system.

D. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

E. Use shipping braces between layers of stacked pipe.

F. Stack piping lengths no more than three layers high.

G. Store field joint materials in original shipping containers in dry area indoors.

H. Support pipes with nylon slings during handling.

1.10 AMBIENT CONDITIONS

A. Section 01 50 00 - Temporary Facilities and Controls: Requirements for ambient condition control facilities for product storage and installation.

B. Maintain storage temperature of 60 to 85 degrees F.

1.11 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.

2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 HORIZONTAL DIRECTIONAL DRILLING

A. Performance and Design Criteria:

1. Drilling Steering System: Remote with continuous electronic monitoring of boring depth and location.

2. Ratio of Reaming Diameter to Pipe Outside Diameter:

a. Nominal Pipe Diameter of 6 Inches and Smaller: Maximum of 1.5.

b. Nominal Pipe Diameter Larger than 6 Inches: Submit recommended ratio and reaming procedures for review.

2.2 WATER SOURCE

A. Water: Potable, obtained from **utility sourc**e.

2.3 UNDERGROUND PIPE MARKERS

A. Trace Wire: Electronic detection materials for nonconductive piping products.

1. Pull back shall include 2 separate strands of tracer wire with each pipe.

2. Tracer wire shall be Copperhead Direct Burial #12 AWG solid, steel core hard drawn extra high strength horizontal directional drill tracer wire.

2.4 MATERIALS

A. Drilling Fluid:

1. Liquid bentonite clay slurry; totally inert with no environmental risk.

B. PVC Piping (casing and water main):

1. Pipe: Comply with AWWA C900, Class 235 (DR18).

2. Fittings: Mechanical joint ductile iron complying with AWWA C111.

3. Joints: Comply with ASTM D3139, compression gasket ring, restrained joint suitable for horizontal directional drilling methods.

4. Materials: Comply with ASTM D1784, minimum cell classification 12545-C.

C. Subsoil Fill: Backfill per trench detail(s) in plans.

2.5 MIXES

A. Grout: As specified in Section 03 60 00 - Grouting.

B. Flowable Fill: As specified in Section 31 23 24 - Flowable Fill.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.

B. Verify that connections to adjacent piping systems or structures, sizes, locations, and invert elevations are according to Drawings.

3.2 PREPARATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation preparation.

B. Request underground utilities to be located and marked within and surrounding construction areas.

C. Maintain access to existing infrastructure and other remaining active installations requiring access. Modify installation as necessary to maintain access.

D. Locate and identify utilities indicated to remain and protect from damage.

E. Notify utility company to remove or relocate utilities.

F. Identify required lines, levels, contours, and data locations.

G. Protect plant life, lawns, and other features remaining as portion of final landscaping.

H. Protect benchmarks, survey control points and existing structures such as fences, sidewalks, paving and curbs from excavating equipment and vehicular traffic.

I. Establish pipe elevations with not less than minimum cover per plans.

3.3 INSTALLATION

A. Dewatering:

1. Intercept and divert surface drainage, precipitation, and groundwater away from excavation using dikes, curb walls, ditches, pipes, sumps, or other approved means.

2. Develop and maintain substantially dry subgrade during drilling and pipe installation.

3. Comply with INDOT and IDEM requirements for discharging water to watercourse, preventing stream degradation, and controlling erosion and sediment.

B. Excavation:

1. Excavate approach trenches and pits according to plans, according to Shop Drawings, and as Site conditions require; minimize number of access pits.

2. Provide sump areas to contain drilling fluids.

3. Install excavation supports as specified in Section 31 23 16 – Excavation and 31 23 17 – Trenching.

4. Restore areas after completion of drilling and carrier pipe installation.

C. Drilling:

1. Drill pilot bore with vertical and horizontal alignment as indicated on Drawings.

2. Survey entire drill path and mark entry and exit locations with stakes. If a magnetic guidance system is used, survey drill path for surface geomagnetic variations or anomalies.

3. Guide drill remotely from ground surface to maintain alignment by monitoring signals transmitted from drill bit.

   a. Monitor depth, pitch, and position.

   b. Adjust drill head orientation to maintain correct alignment.

4. Inject drilling fluid into bore to stabilize hole, remove cuttings, and lubricate drill bit and pipe.

5. Continuously monitor drilling fluid pumping rate, pressure, viscosity, and density while drilling pilot bore, back reaming, and installing pipe to ensure adequate removal of soil cuttings and stabilization of bore.

   a. Provide relief holes when required to relieve excess pressure.

   b. Minimize heaving during pullback.

6. Verification of Accuracy:

   a. Calibrate and verify electronic monitor accuracy during first 50 feet of bore in presence of Engineer before proceeding with other drilling.

   b. Excavate minimum of two test pits spaced along first 50 feet of bore to verify required accuracy.

   c. If required accuracy is not met, adjust equipment or provide new equipment capable of meeting required accuracy.

7. After completing pilot bore, remove drill bit.

D. Drilling Obstructions:

1. If obstructions are encountered during drilling, notify Engineer immediately. Do not proceed around obstruction without Engineer's approval.

2. For conditions requiring more than 3 feet of deviation in horizontal alignment, submit revised Shop Drawings to Engineer for approval before resuming Work.

3. Maintain adjusted bore alignment within easement or right-of-way.

E. Pipe:

1. Install reamer and pipe pulling head; select reamer with minimum bore diameter required for pipe installation.

2. Attach pipe to pipe pulling head and pull reamer and pipe to entry pit along pilot bore.

3. Inject drilling fluid through reamer to stabilize bore and lubricate pipe.

4. Install piping with horizontal and vertical alignment as shown on Drawings.

5. Protect and support pipe being pulled into bore such that pipe moves freely and is not damaged during installation.

6. Do not exceed pipe manufacturer's recommended pullback forces.

7. Trace Wire:

a. Install two trace wires continuous with each bore.

b. Splice trace wire only at intermediate bore pits.

c. Tape or insulate trace wire to prevent corrosion and maintain integrity of pipe detection.

d. Terminate trace wire for each pipe run at structures along pipe system.

e. Provide extra length of trace wire at each structure such that trace wire can be pulled 3 feet out top of structure for connection to detection equipment.

f. Test trace wire for continuity for each bore before acceptance.

8. Provide sufficient length of pipe to extend past termination point to allow connection to other pipe sections (if necessary).

9. Allow minimum of 24 hours for stabilization after installing pipe before making connections to pipe.

10. Mark location and depth of bore with spray paint on paved surfaces and on wooden stakes on non-paved surfaces at 25-foot intervals.

F. Slurry Removal and Disposal:

1. Contain excess drilling fluids at entry and exit points until recycled or removed from Site; provide recovery system to remove drilling spoils from access pits.

2. Drilling Spoils:

a. Remove, transport, and legally dispose of drilling spoils.

b. Do not discharge drilling spoils in sanitary sewers, storm sewers, or other drainage systems.

c. When drilling in suspected contaminated soil, test drilling fluid for contamination before disposal.

3. If drilling fluid leaks to surface, immediately contain leak and barricade area from vehicular and pedestrian travel before resuming drilling operations.

4. Complete cleanup of drilling fluid at end of each working day.

G. Backfilling:

1. Install backfill per trench detail(s) in plans, to contours and elevations as indicated

3.4 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Requirements for tolerances.

B. Maximum Variation from Horizontal Position: 12 inches.

C. Maximum Variation from Vertical Elevation: 2 inches.

D. Minimum Horizontal and Vertical Clearance from Other Utilities: 12 inches.

E. Deviation:

1. When pipe installation deviates beyond specified tolerances, abandon bore, remove installed pipe, rebore, and reinstall pipe in correct alignment.

2. Fill abandoned bores greater than 3 inches in diameter with grout or flowable fill material.

3.5 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for inspecting and testing.

B. Upon completion of pipe installation, test pipe according to following:

1. Sanitary Sewer Pipe Testing: As specified in Section 33 01 30.13 - Sewer and Manhole Testing and Section 33 31 13 - Public Sanitary Utility Sewerage Piping.

2. Water Distribution Pipe Testing: As specified in Section 33 11 13 - Public Water Utility Distribution Piping.

C. If tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

D. Manufacturer Services: Furnish services of manufacturer's representative experienced in installation of products furnished under this Section for not less than one day on Site for installation, inspection, startup, field testing, and instructing Owner's personnel in maintenance of equipment.

E. Certify that equipment for drilling has been properly set up and is ready for drilling.

3.6 CLEANING

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for cleaning.

B. Upon completion of drilling and pipe installation, remove drilling spoils, debris, and unacceptable material from approach trenches and pits. Clean up excess slurry from ground.

C. Restore approach trenches and pits to original condition.

D. Remove temporary facilities for drilling operations as specified in Section 01 50 00 - Temporary Facilities and Controls.

END OF SECTION

SECTION 33 05 63

PRECAST CONCRETE VALVE AND METER VAULTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Precast concrete valve and meter vaults.

2. Aluminum access hatches.

B. Related Requirements:

1. Section 31 05 16 - Aggregates for Earthwork: Bedding fill type.

2. Section 33 14 13 - Public Water Utility Distribution Piping: Execution requirements for piping Work as required by this Section.

1.2 REFERENCE STANDARDS

A. ASTM International:

1. ASTM A48 - Standard Specification for Gray Iron Castings.

2. ASTM A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.

3. ASTM A536 - Standard Specification for Ductile Iron Castings.

4. ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

5. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

6. ASTM C33 - Standard Specification for Concrete Aggregates.

7. ASTM C150 - Standard Specification for Portland Cement.

8. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.

9. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.

10. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.

11. ASTM C858 – Standard Specification for Underground Precast Concrete Utility Structures.

12. ASTM C890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.

13. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.

14. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

15. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3).

16. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3).

17. ASTM D4104 - Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests).

18. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.3 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Requirements for coordination.

B. Coordinate Work with Hillsdale Water Corporation, Vermillion Rise Mega Park and Vermillion County Jail Addition & Renovation General Contractor.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data on valve vaults, meter boxes, and similar designated structures.

C. Shop Drawings: Indicate plan, location, and inverts of connecting piping.

D. Manufacturer's Certificate: Certify that precast concrete valve vaults and meter boxes meet or exceed ASTM standards and specified requirements.

E. Manufacturer Instructions: Submit special procedures for precast concrete valve vaults and meter boxes installation.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Qualifications Statement:

1. Submit qualifications for manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for closeout procedures.

B. Project Record Documents: Record actual locations and inverts of buried pipe, components, and connections.

1.6 QUALITY ASSURANCE

A. Perform Work according to Indiana Department of Environmental Management and the City of Frankfort standards.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

C. Transport and handle precast concrete units with equipment designed to protect units from damage.

D. Storage:

1. Store precast concrete valve vaults and meter boxes according to manufacturer instructions.

2. Do not place concrete units in position to cause overstress, warping, or twisting.

PART 2 - PRODUCTS

2.1 DESIGN REQUIREMENTS

A. Performance and Design Criteria:

1. Watertight, Precast, Reinforced, Air-Entrained Concrete Structures:

a. Design to ASTM C890 live loading and installation conditions.

b. Manufactured to conform to ASTM C858.

2. Minimum 28-Day Compressive Strength: 5,000 psi.

3. Honeycombed or retempered concrete is not permitted.

2.2 PRECAST CONCRETE VALVE AND METER VAULTS

A. Valve Vault and Meter Box Frames and Covers:

1. Aluminum Access Hatches:

a. Manufacturers:

1) Bilco Company

2) Halliday Products

3) USF Fabrication

b. Design Live Loading: 300 psf or better with maximum deflection of 1/150th of the span

c. Cover: ¼" aluminum diamond pattern

d. Frame: Extruded aluminum with bend down anchor tabs round perimeter

e. Hinges: Tamperproof 316 stainless steel

f. Drain Coupling: 1-1/2", located in channel frame

g. Lifting Mechanism: Compression spring operators enclosed in telescopic tubes for smooth operation

h. Lift Handle: Removable

i. Hardware: 316 stainless steel

j. Finishes: Factory finish shall be mill finish aluminum with bituminous coating applied to exterior of the frame.

k. Installation: Frame to be cast into concrete vault per manufacturer's instructions

B. Access Steps:

1. Rungs: Copolymer polypropylene with ½ inch grade 60 steel reinforcement.

2. Formed integral with concrete sections.

3. Width:

a. 12 inches; or

b. As indicated on Drawings.

4. Spacing:

a. The distance between the top of casting and the first step shall be not more than 24" and all other steps spaced at 16 inches o.c. vertically, set into structure wall; or

b. As indicated on Drawings.

2.3 MATERIALS

A. Portland Cement:

1. ASTM C150, Type II.

B. Coarse Aggregates:

1. ASTM C33

2. Graded 1 inch to No. 4 sieve.

C. Sand:

1. ASTM C33

2. Fineness Modulus: 2.35.

D. Water:

1. Potable.

2. Clean and free of injurious amounts of acids, alkalis, salts, organic materials, and substances incompatible with concrete or steel.

E. Air-Entraining Admixtures: ASTM C260

F. Reinforcing Steel:

1. Deformed Bars: ASTM A615 Grade 60

2. Welded Wire Fabric: ASTM A185

G. Joint Sealant:

1. ASTM C990

2.4 FABRICATION

A. Fabricate precast reinforced concrete structures according to ASTM C858, to dimensions indicated on Drawings, and to specified design criteria.

2.5 MIXES

A. Design concrete mix to produce required concrete strength, air-entrainment, watertight properties, and loading requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.

B. Verify that piping connections, sizes, locations, and inverts are as indicated on Drawings.

3.2 PREPARATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation preparation.

B. Ream pipe ends and remove burrs.

C. Remove scale and dirt from components before assembly.

D. Establish invert elevations for each component in system.

E. Hand trim excavation to suit valve vaults and meter boxes; remove stones, roots, and other obstructions.

3.3 INSTALLATION

A. Tank and Bedding:

1. Excavate as specified in Section 31 23 16 – Excavation for Work of this Section.

2. Hand trim excavation for accurate placement of vaults and meter boxes to elevations indicated.

3. Place bedding material level in one continuous layer to compacted depth as indicated on Drawings and compact to 95 percent maximum density.

4. Backfill around sides of vaults and meter boxes, tamp in place, and compact to 95 percent maximum density.

5. Maintain optimum moisture content of bedding material to attain required compaction density.

6. Install vaults and related components on bedding.

B. Connect piping.

3.4 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for inspecting and testing.

B. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

END OF SECTION

SECTION 33 12 16

WATER UTILITY DISTRIBUTION VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Valves.
2. Valve boxes.
3. Post Indicators.

B. Related Requirements:

1. Section 03 30 00 - Cast-in-Place Concrete: Concrete for thrust restraints.
2. Section 33 13 00 - Disinfecting of Water Utility Distribution: Flushing and disinfection requirements.
3. Section 33 14 13 - Public Water Utility Distribution Piping: Piping trenching, backfilling, and compaction requirements.

1.2 REFERENCE STANDARDS

A. American Water Works Association:

1. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service.
2. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service.
3. AWWA C550 - Protecting Interior Coatings for Valves and Hydrants.
4. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances.

B. NSF International:

1. NSF 61 - Drinking Water System Components - Health Effects.
2. NSF 372 - Drinking Water System Components - Lead Content.

1.3 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Requirements for coordination.

B. Coordinate Work of this Section with AWWA and IDEM standards and utilities within construction area.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit manufacturer's latest published literature. Include illustrations, installation and maintenance instructions, and parts lists.

C. Shop Drawings: Submit description of proposed installation.

D. Manufacturer's Certificate: Certify that product(s) meet or exceed specified requirements.

E. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Qualifications Statements:

1. Submit qualifications for manufacturer and installer.

2. Submit manufacturer's approval of installer.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.

B. Project Record Documents: Record actual locations of valves.

C. Operation and Maintenance Data: Submit information for valves.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for maintenance materials.

B. Tools: Furnish one valve wrench of each type require and of required length to Owner.

1.7 QUALITY ASSURANCE

A. Cast manufacturer's name, pressure rating, and year of fabrication into valve body.

B. Perform Work according to AWWA standards.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

B. Installer: Company specializing in performing Work of this Section with minimum three years' documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Prepare valves and accessories for shipment according to applicable AWWA standards.

C. Seal valve and ends to prevent entry of foreign matter.

D. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

E. Storage:

1. Store materials in areas protected from weather, moisture, or other potential damage.

2. Do not store materials directly on ground.

F. Handle products carefully to prevent damage to interior or exterior surfaces.

PART 2 - PRODUCTS

2.1 RESILIENT WEDGE GATE VALVES

A. Manufacturers:

1. Clow, Kennedy, Mueller or approved equal.

2. Substitutions: As specified in Section 01 60 00 - Product Requirements

B. Description:

1. Comply with AWWA C509.

2. Materials:

a. Body: Ductile iron.

3. Seats: Resilient.

4. Stem:

a. Type: Non-rising.

b. Material: Bronze.

5. Operation:

a. Square operating nut.

b. Open counterclockwise unless otherwise indicated.

6. End Connections: Mechanical joint
7. Coatings:
    a. Comply with AWWA C550.
    b. Interior and exterior.
8. Pressure Rating:
    a. 12-inch Diameter and Smaller: 200 psig.
    b. 16-inch Diameter and Larger: 150 psig.

2.2 VALVE BOXES

A. Manufacturers:
1. Ford Meter Box Company, Mueller, Tyler or approved equal.
2. Substitutions: As specified in Section 01 60 00 - Product Requirements.

B. Description:
1. 12-inch Diameter Valves and Smaller:
    a. Material: Cast iron.
    b. Type: Two-piece, screw.
2. Valves Larger than 12-inch Diameter:
    a. Material: Cast iron.
    b. Type: Three-piece, screw.
    c. Base: Round.
3. Lid Inscription: WATER.

2.3 POST INDICATORS

A. Manufacturers:
1. American Flow Control, Mueller or approved equal.
2. Substitutions: As specified in Section 01 60 00 – Product Requirements.

B. Description:
1. 14-inch Diameter Valves and Smaller:

a. Type: 2-piece, adjustable, tamper-proof design

b. Materials:

1) Upper Barrel: Steel

2) Lower Barrel l: PVC

3) Post Head: Cast Iron

4) Bell: Cast Iron

c. Coatings: Required per manufacturer recommendations

d. Accessories:

1) Provide two (2) Master Lock 6127 ProSeries padlocks, 2-5/8” wide, 1-7/8” shackle, keyed differently. Two (2) sets of keys shall provided per padlock, with one set delivered to Hillsdale Water Corporation and one set delivered to Vermillion Rise Mega Park.

2) Provide two (2) weatherproof, UV resistant, fade resistant labels, 3” wide by 12” high, blue background with white lettering, with one installed on each post, with the following text:

a) “Hillsdale Water Corporation”

b) “Vermillion Rise Mega Park”

2.4 ACCESSORIES

A. Concrete for Thrust Restraints: Concrete type as specified in Section 03 30 00 - Cast-in-Place Concrete.

B. Valve Box Aligner: High-strength plastic device designed to automatically center valve box base and to prevent it from shifting off center during backfilling.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.

B. Determine exact location and size of valves from Drawings.

C. Verify that invert elevations of existing work prior to excavation and installation of valves are as indicated on Drawings.

3.2 PREPARATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation preparation.

B. Conduct operations to not interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures, utilities, and landscape in immediate or adjacent areas.

C. Identify required lines, levels, contours, and datum locations.

D. Locate, identify, and protect from damage utilities to remain.

E. Do not interrupt existing utilities without permission and without making arrangements to provide temporary utility services.

1. Notify Architect/Engineer not less than 5 days in advance of proposed utility interruption.

2. Do not proceed without written permission from Architect/Engineer.

3.3 INSTALLATION

A. Perform trench excavation, backfilling, and compaction as specified in Section 33 11 13 - Public Water Utility Distribution Piping.

B. Install valves in conjunction with pipe laying.

C. Set valves plumb.

D. Provide buried valves with valve boxes installed flush with finished grade.

E. Disinfection of Water Piping System:

1. Flush and disinfect system as specified in Section 33 13 00 - Disinfecting of Water Utility Distribution.

3.4 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for inspecting and testing.

B. Pressure test system according to AWWA C600 and following:

1. Test Pressure: Not less than 200 psig or 50 psi in excess of maximum static pressure, whichever is greater.

2. Conduct hydrostatic test for at least two hours.

3. Slowly fill section to be tested with water and expel air from piping at high points.

4. Install corporation cocks at high points.

5. Close air vents and corporation cocks after air is expelled.

6. Raise pressure to specified test pressure.

7. Observe joints, fittings, and valves under test.

8. Remove and replace cracked pipes, joints, fittings, and valves that show visible leakage and retest.

9. Correct visible deficiencies and continue testing at same test pressure for additional two hours to determine leakage rate, maintaining test pressure within plus or minus 5.0 psi.

10. Leakage is defined as quantity of water supplied to piping as necessary to maintain test pressure during testing period.

11. Compute maximum allowable leakage using following formula:

12.

L = [SD x sqrt(P)]/C
L = testing allowance, gph
S = length of pipe tested, feet
D = nominal diameter of pipe, inches
P = average test pressure during hydrostatic test, psig
C = 148,000
If pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.

13. If test of pipe indicates leakage greater than that allowed, locate source of leakage, make corrections, and retest until leakage is within allowable limits.

14. Correct visible leaks regardless of quantity of leakage.

END OF SECTION

SECTION 33 12 19

WATER UTILITY DISTRIBUTION HYDRANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire hydrants
2. Flush hydrants

B. Related Requirements:

1. Section 03 30 00 - Cast-in-Place Concrete: Concrete for thrust restraints.
2. Section 31 05 16 - Aggregates for Earthwork: Aggregate for hydrant drainage.
3. Section 31 23 17 - Trenching: Trenching, backfilling, and compaction requirements.
4. Section 33 13 00 - Disinfecting of Water Utility Distribution: Flushing and disinfection requirements.

1.2 REFERENCE STANDARDS

A. American Water Works Association:

1. AWWA C502 - Dry-Barrel Fire Hydrants.
2. AWWA C503 - Wet-Barrel Fire Hydrants.
3. AWWA C550 - Protective Interior Coatings for Valves and Hydrants.
4. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances.

B. National Fire Protection Association:

1. NFPA 291 - Recommended Practice for Fire Flow Testing and Marking of Hydrants.

1.3 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Requirements for coordination.

B. Coordinate Work of this Section with IDEM and AWWA standards and utilities within construction area.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit manufacturer's latest published literature, including illustrations, installation and maintenance instructions, and parts lists.

C. Shop Drawings: Submit description of proposed installation.

D. Manufacturer's Certificate: Certify that product(s) meet or exceed specified requirements.

E. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Qualifications Statements:

1. Submit qualifications for manufacturer and installer.

2. Submit manufacturer's approval of installer.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.

B. Project Record Documents: Record actual locations of fire hydrants and service valves.

C. Operation and Maintenance Data: Submit data for hydrants.

1.6 QUALITY ASSURANCE

A. Perform Work according to AWWA standards.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

B. Installer: Company specializing in performing Work of this Section with minimum three years' documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Prepare hydrants and accessories for shipment according to AWWA standards and seal hydrant and ends to prevent entry of foreign matter.

C. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

D. Storage:

1. Store materials in areas protected from weather, moisture, or potential damage.

2. Do not store materials directly on ground.

E. Handle materials in a way that prevents damage to interior and exterior surfaces.

PART 2 - PRODUCTS

~~2.1 FIRE HYDRANTS~~

~~A. Manufacturers:~~

~~1. American, Kennedy, Mueller or approved equal.~~

~~2. Substitutions: As specified in Section 01 60 00 - Product Requirements.~~

~~B. Dry-Barrel Breakaway Type:~~

~~1. Comply with AWWA C502.~~

~~2. Body: Cast iron.~~

~~3. Valve: Compression type.~~

~~4. Burial Depth: As indicated on Drawings.~~

~~5. Inlet Connection Size: 6 inches.~~

~~6. Valve Opening: 5-1/4 inches in diameter.~~

~~7. End Connections: Mechanical joint~~

~~8. Bolts and Nuts: Stainless Steel~~

~~9. Interior Coating: Comply with AWWA C550.~~

~~10. Direction of Opening: Counterclockwise unless otherwise indicated.~~

~~C. Hose Connections:~~

~~1. One pumper, two hose nozzles.~~

~~2. Pumper nozzle shall be 5" Storz connection.~~

~~3. Hose nozzle shall be 2 ½" standard hose thread.~~

~~4. Attach nozzle caps by separate chains.~~

~~D. Finishes:~~

~~1. Primer and two coats of enamel.~~

~~2. Color: According to Owner requirements.~~

2.2 FLUSH HYDRANTS

A. Manufacturers:

1. American, Kennedy, Mueller or approved equal.

2. Substitutions: As specified in Section 01 60 00 - Product Requirements.

B. Dry-Barrel Breakaway Type:

1. Comply with AWWA C502.

2. Body: Cast iron.

3. Valve: Compression type.

4. Burial Depth: As indicated on Drawings.

5. Inlet Connection Size: 4 inches.

6. Valve Opening: 4-1/2 inches in diameter.

7. End Connections: Mechanical joint

8. Bolts and Nuts: Stainless Steel

9. Interior Coating: Comply with AWWA C550.

10. Direction of Opening: Counterclockwise unless otherwise indicated.

C. Hose Connections:

1. Two hose nozzles.

2. Hose nozzle shall be 2 ½" standard hose thread.

3. Attach nozzle caps by separate chains.

D. Finishes:

1. Primer and two coats of enamel.

2. Color: According to Owner requirements.

2.3 ACCESSORIES

A. Concrete for Thrust Restraints: Concrete type as specified in Section 03 30 00 - Cast-in-Place Concrete.

B. Aggregate: Aggregate for hydrant drainage as specified in Section 31 05 16 - Aggregates for Earthwork.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.

B. Verify exact location and size of hydrants from Drawings.

C. Obtain clarification and directions from Engineer prior to execution of Work.

D. Verify that invert elevations of existing work are as indicated on Drawings prior to excavation and installation of fire hydrants.

3.2 PREPARATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation preparation.

B. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures, utilities, and landscape in immediate or adjacent areas.

C. Identify required lines, levels, contours, and datum locations.

D. Locate, identify, and protect from damage utilities to remain.

E. Do not interrupt existing utilities without permission and without making arrangements to provide temporary utility services.

1. Notify Engineer not less than 5 days in advance of proposed utility interruption.

2. Do not proceed without written permission from Engineer.

3.3 INSTALLATION

A. Perform trench excavation, backfilling, and compaction as specified in Section 31 23 17 - Trenching.

B. Provide support blocking and drainage gravel while installing fire hydrants; do not block drain hole.

C. Set fire hydrants plumb with pumper nozzle facing roadway.

D. Set fire hydrants with centerline of pumper nozzle 18 inches above finished grade, and with safety flange not more than 6 inches nor less than 2 inches above grade.

E. Paint hydrants according to color scheme of local authorities having jurisdiction.

F. After hydrostatic testing, flush hydrants and check for proper drainage.

G. Installation Standards: Install Work according to AWWA standards.

H. Disinfection of Water Piping System:

1. Flush and disinfect system as specified in Section 33 13 00 - Disinfecting of Water Utility Distribution.

3.4 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for inspecting and testing.

B. Pressure test system according to AWWA C600 and following:

1. Test Pressure: Not less than 200 psig or 50 psi in excess of maximum static pressure, whichever is greater.

2. Conduct hydrostatic test for at least two hours.

3. Slowly fill section to be tested with water and expel air from piping at high points.

4. Install corporation cocks at high points.

5. Close air vents and corporation cocks after air is expelled.

6. Raise pressure to specified test pressure.

7. Observe joints, fittings, and valves under test.

8. Remove and replace cracked pipes, joints, fittings, and valves that show visible leakage and retest.

9. Correct visible deficiencies and continue testing at same test pressure for additional two hours to determine leakage rate, maintaining test pressure within plus or minus 5.0 psi.

10. Leakage is defined as quantity of water supplied to piping as necessary to maintain test pressure during testing period.

11. Compute maximum allowable leakage using following formula:

12.

L = [SD x sqrt(P)]/C
L = testing allowance, gph
S = length of pipe tested, feet
D = nominal diameter of pipe, inches
P = average test pressure during hydrostatic test, psig
C = 148,000

If pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.

13. If test of pipe indicates leakage greater than that allowed, locate source of leakage, make corrections, and retest until leakage is within allowable limits.

14. Correct visible leaks regardless of quantity of leakage.

END OF SECTION

SECTION 33 13 00

DISINFECTING OF WATER UTILITY DISTRIBUTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Disinfection of potable water distribution and transmission systems.

2. Testing and reporting of results.

1.2 REFERENCE STANDARDS

A. American Water Works Association:

1. AWWA B300 - Hypochlorites.

2. AWWA B302 - Ammonium Sulfate.

3. AWWA B303 - Sodium Chlorite.

4. AWWA C651 - Disinfecting Water Mains.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit procedures, proposed chemicals, and treatment levels.

C. Manufacturer's Certificate: Certify that product(s) meet or exceed specified requirements.

D. Certify that cleanliness of water distribution system meets or exceeds specified requirements.

E. Certify that water conforms or fails to conform to bacterial standards of authority having jurisdiction.

F. Certify that water conforms to quality standards of authority having jurisdiction.

G. Test and Evaluation Reports: Indicate testing results comparative to specified requirements.

H. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

I. Qualifications Statements:

1. Submit qualifications for water treatment firm and testing firm.

1.4 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.

B. Disinfection Report:

1. Type and form of disinfectant used.
2. Date and time of disinfectant injection start and time of completion.
3. Test locations.
4. Name of person collecting samples.
5. Initial and 24-hour disinfectant residuals in treated water in ppm for each outlet tested.
6. Date and time of flushing start and completion.
7. Disinfectant residual after flushing in ppm for each outlet tested.

C. Bacteriological Report:

1. Date issued, project name, and testing laboratory name, address, and telephone number.
2. Time and date of water sample collection.
3. Name of person collecting samples.
4. Test locations.
5. Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
6. Coliform bacteria test results for each outlet tested.
7. Submit bacteriologist's signature and authority associated with testing.

1.5 QUALITY ASSURANCE

A. Perform Work according to AWWA C651.

1.6 QUALIFICATIONS

A. Water Treatment Firm: Company specializing in disinfecting potable water systems specified in this Section with minimum three years' documented experience.

B. Testing Firm: Company specializing in testing potable water systems, certified by State of Indiana.

PART 2 - PRODUCTS

2.1 DISINFECTION CHEMICALS

A. Chemicals:

1. Liquid chlorine

2. Hypochlorite: Comply with AWWA B300.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.

B. Verify that piping system has been cleaned, inspected, and pressure tested.

C. Perform scheduling and disinfecting activity with startup, water pressure testing, adjusting and balancing, and demonstration procedures, including coordination with related systems.

3.2 INSTALLATION

A. Before being placed in service, all new water distribution systems, or extensions to existing systems, or any valved section of such extension or any replacement in the existing water distribution system shall be chlorinated in accordance with AWWA C-651.

B. Provide and attach required equipment to perform Work of this Section.

C. Perform disinfection of water distribution system and installation of system and pressure testing as specified in Section 33 11 16 - Site Water Utility Distribution Piping.

D. Testing shall follow installation as promptly as may be feasible.

E. Testing may be done during flushing operations or during sterilization at the Contractors option, but sterilization may not be done prior to flushing.

F. Either of the following methods of procedure in chlorinating (arranged in the order of preference) shall be followed, subject to the approval of the Engineer:

1. Liquid chlorine gas-water mixture

2. Calcium hypochlorite and water mixture

G. Prior to chlorination, all dirt and foreign matter shall be removed by a thorough flushing through the hydrants, or by other approved means. Each valved section of newly laid pipe shall be flushed independently when possible.

H. During the process of chlorinating newly laid water pipe, all valves, service connections and other appurtenances shall be operated while the pipe line is filled with the chlorinating agent.

I. Treated water shall be retained in the pipe long enough to destroy all non-spore-forming bacteria. This period shall be at least twenty-four (24) hours and preferably longer as may be directed. After the chlorine treated water has been retained for the required time, the chlorine residual at pipe extremities and at other representative points shall be at least ten (10) parts per million.

J. Following chlorination, all treated water shall be thoroughly flushed from the newly laid pipe line at its extremities until the replacement water throughout its length shall, upon test, both chemically and bacteriologically, be proven equal to the water quality served the public from the existing water supply system, and/or approved by the State Board of Health.

K. In the case of new systems, flushing of the mains shall be continued until all trace of the chlorine added during chlorination of the mains shall have been removed. Two samples shall then be taken, at points designated by the Engineer, at 24 hour intervals. These samples shall be sent to a certified testing laboratory for analysis. Sampling shall continue until two (2) consecutive samples at each point have been approved by the State Board of Health, ie. no coliform present.

L. Should the initial treatment, in the opinion of the Engineer, prove ineffective, the chlorination procedure shall be repeated until confirmed tests show the water sampled from the newly laid pipe conforms to the requirements of Paragraph F, above.

M. Unless the Engineer shall direct otherwise, cuts made in existing pipe lines for the insertion of valves, fittings, repairs, or for any other purpose, shall be chlorinated by shaking a quantity of calcium hypochlorite, predetermined by the Engineer, into the pipe on each side of the cut-in. After slowly filling the section and reversing the flow, the chlorinated water shall be retained for several hours, and then flushed until no odor of chlorine can be detected in the waste water. Where the piping arrangement will not permit this procedure, contractor may wash the connected pipe, fittings and valves in a 50 ppm chlorine solution before installation.

N. After satisfactory chlorination by either of the alternative procedures, the consumers may be served from the newly laid pipe line or the service may be resume don existing pipe lines.

O. All labor and material required in successfully chlorinating the new or repaired work shall be furnished by the Contractor. He shall also be responsible for power bills incurred in flushing and chlorinating the mains, and appurtenances unless otherwise specifically provided. Charges will be levied for bacteriological testing. Any such charges shall be paid by the Contractor.

P. Application of Liquid Chlorine:

1. A chlorine gas-water mixture shall be applied by means of a solution-feed chlorinating device, or, if approved by the Engineer the gas shall be fed directly from a chlorine cylinder equipped with proper device for regulating the rate of flow and the effective diffusion of gas within the pipe. (Chlorination with the gas-water mixture is preferred to direct feed.)

2. The preferable point of application of the chlorinating agent shall be at the beginning of the pipe line extension, or any valved section of it, and through a corporation stop inserted in the horizontal axis of the newly laid pipe. The water injector for delivering the gas-water mixture into the pipe shall be supplied from a tap on the pressure side of the gate valve controlling the flow into the pipe line extension. In a new system, application may

be at the pumping station, or the elevated tank, or the standpipe, or the reservoir; see Special Conditions.

3. Water from the existing distribution system or other source of supply shall be controlled to flow very slowly into the newly laid pipe line during the application of chlorine. The rate of chlorine water mixture flow shall be in such proportion to the rate of water entering the pipe that the chlorine dose applied to the water entering the newly laid pipe shall be at least 50 parts per million.

4. Back pressure, causing a reversal of flow in the pipe treated, shall be prevented.

Q. Chlorinated Water

1. Chlorinated water flushed from water mains shall not be discharged into the environment or the local sanitary sewer lines unless it is properly treated. The CONTRACTOR shall notify the water utility of the dechlorination methods planned before proceeding. Any damages resulting to the environment from the improper disposal or treatment of chlorinated water shall be the responsibility of the CONTRACTOR.

R. Replace permanent system devices that were removed for disinfection.

3.3 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for inspecting and testing.

B. Disinfection, Flushing, and Sampling:

1. Disinfect pipeline installation according to AWWA C651.

2. Use of liquid chlorine is not permitted.

3. Upon completion of retention period required for disinfection, flush pipeline until chlorine concentration in water leaving pipeline is no higher than that generally prevailing in existing system or is acceptable for domestic use.

4. Disposal:

a. Legally dispose of chlorinated water.

b. When chlorinated discharge may cause damage to environment, apply neutralizing chemical to chlorinated water to neutralize chlorine residual remaining in water.

5. After final flushing and before pipeline is connected to existing system or placed in service, employ an approved independent testing laboratory to sample, test, and certify that water quality meets quality standards of authority having jurisdiction.

END OF SECTION

SECTION 33 14 13

PUBLIC WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings
2. Tapping sleeves and valves.
3. Underground pipe markers.
4. Pipe support systems.
5. Bedding and cover materials.

B. Related Requirements:

1. Section 31 05 13 - Soils for Earthwork: Soils for backfill in trenches.
2. Section 31 05 16 - Aggregates for Earthwork: Aggregate for backfill in trenches.
3. Section 31 23 16 - Excavation: Product and execution requirements for excavation and backfill required by this Section.
4. Section 31 23 17 - Trenching: Execution requirements for trenching required by this Section.
5. Section 33 05 63 - Precast Concrete Valve Vaults and Meter Boxes: Precast concrete valve vaults and meter boxes for valve and meter installation.
6. Section 33 13 00 - Disinfecting of Water Utility Distribution: Disinfection of water piping.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials:

1. AASHTO T 180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. American Society of Mechanical Engineers:

1. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

C. ASTM International:

1. ASTM A36 - Standard Specification for Carbon Structural Steel.

2. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.

3. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3).

4. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3).

5. ASTM D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

6. ASTM D3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.

7. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

8. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

D. American Water Works Association:

1. AWWA C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.

2. AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

3. AWWA C110 - Ductile-Iron and Gray-Iron Fittings.

4. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

5. AWWA C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.

6. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast.

7. AWWA C153 - Ductile-Iron Compact Fittings.

8. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances.

9. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.

10. AWWA C700 - Cold-Water Meters - Displacement Type, Bronze Main Case.

11. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution.

12. AWWA C901 - Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13 mm) Through 3 In.(76 mm), for Water Service.

13. AWWA C905 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm) for Water Transmission and Distribution.

E. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP-60 - Connecting Flange Joints between Tapping Sleeves and Tapping Valves.

F. National Fire Protection Association:

1. NFPA 24 - Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data on pipe materials, pipe fittings, valves, and accessories.

C. Shop Drawings: Indicate piping layout, including piping specialties.

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

F. Preconstruction Video:

1. Submit digital video files of Work areas and material storage areas.

1.4 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for submittals.

B. Project Record Documents: Record actual locations of piping mains, valves, connections, and invert elevations.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 QUALITY ASSURANCE

A. Valves: Mark valve body with manufacturer's name and pressure rating.

B. Perform Work according to Indiana Department of Environmental Management and City of Frankfort Standards.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver and store valves in shipping containers with manufacturer's labeling in place and inspect for damage.

C. Block individual and stockpiled pipe lengths to prevent moving.

D. Do not place pipe or pipe materials on private property or in areas obstructing pedestrian or vehicle traffic.

E. Store polyethylene and PVC materials out of sunlight.

1.7 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.

2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 WATER PIPING

A. PVC:

1. Comply with AWWA C900 and AWWA C905, DR18.

2. Fittings:

a. Material: Ductile iron, AWWA C110.

b. Compact Fittings: Comply with AWWA C153.

c. Coating and Lining:

1) Bituminous Coating: Comply with AWWA C110.

2) Cement Mortar Lining: Comply with AWWA C104, double thickness.

3. PVC pipe for horizontal directional drilling (casing and water main) shall be Certa-Lok or approved equal.

4. Joints:

a. Comply with ASTM D3139.

b. Seals: PVC flexible elastomeric.

c. Restrained Joints shall be US Pip FieldLok, EBAA Megalug, or Romac Grip Ring.

d. Solvent-cement couplings are not permitted.

e. Fusible PVC is not permitted.

B. Ductile-Iron Pipe (where applicable on Drawings):

1. Comply with AWWA C151.
2. Bituminous Outside Coating: Comply with AWWA C151.
3. Pipe Mortar Lining:
    a. Comply with AWWA C104.
    b. Standard thickness.
4. Polyethylene Encasement: Comply with AWWA C105.
5. Pipe Class:
    a. Comply with AWWA C151.
    b. Pressure Class 350.
6. Fittings:
    a. Material: Ductile iron, AWWA C110.
    b. Compact Fittings: Comply with AWWA C153.
    c. Coating and Lining:
        1) Bituminous Coating: Comply with AWWA C110.
        2) Cement Mortar Lining: Comply with AWWA C104, double thickness.
7. Joints:
    a. Mechanical, Push-on, and Restrained Push-on Joints: Comply with AWWA C111.
    b. Flanged Joints: Comply with AWWA C115.
    c. Restrained Joints shall be US Pip FieldLok, EBAA Megalug, or Romac Grip Ring.
8. Gaskets
    a. Gaskets for mechanical joints and push-on joints shall conform to AWWA C111.

2.2 TAPPING SLEEVES AND VALVES

A. Tapping Sleeves:

1. Description:
    a. Material: Stainless Steel.
    b. Type: Split Sleeve

c. Outlet Flange Dimensions and Drilling: Comply with ASME B16.1, Class 125.

B. Tapping Valves:

1. Description:

a. Comply with AWWA C500.

b. Type: Metal Seated, with non-rising stem.

c. Inlet Flanges: Comply with ASME B16.1, Class 125.

d. Mechanical Joint Outlets: Comply with AWWA C111.

e. Gate rings and body-seat rings shall be oversized to permit entry and exit of tapping machine cutters

f. Valve shall open clockwise (right) and have 2-inch operating nut.

2. Mark manufacturer's name and pressure rating on valve body.

~~2.3 AIR RELEASE VALVES~~

~~A. Manufacturers:~~

~~1. Val-Matic~~

~~2. Cla-Val~~

~~3. Or Approved Equal~~

~~4. Substitutions: As specified in Section 01 60 00 - Product Requirements.~~

~~B. Description: Ductile iron body, stainless steel float.~~

2.4 UNDERGROUND PIPE MARKERS

A. Plastic Ribbon Tape:

1. Brightly colored, continuously printed.

2. Minimum 6 inches wide by 4 mil thick.

3. Manufactured for direct burial service.

B. Trace Wire:

1. Electronic detection materials for nonconductive piping products.

2. Unshielded, 10 AWG, THWN-insulated copper wire.

2.5 PRECAST CONCRETE VALVE VAULTS AND METER BOXES

A. Precast Concrete Valve Vaults and Meter Boxes: As specified in Section 33 05 63 - Precast Concrete Valve Vaults and Meter Boxes.

2.6 VALVE BOXES

A. Manufacturers:

1. Clow.

2. Substitutions: As specified in Section 01 60 00 - Product Requirements.

B. Description: Valve boxes and covers containing valve extensions as indicated on Drawings.

1. 5inch diameter with a minimum thickness of 3/16-inch.

2. Box shall rest of brick or masonry units and be centered on the valve. Unit shall be plumb.

C. Type: Cast iron; three piece screw type.

D. Covers: Marked WATER to indicate utility.

2.7 PIPE SUPPORTS AND ANCHORING

A. Metal for Pipe Support Brackets: Stainless steel.

B. Metal Tie Rods and Clamps or Lugs: Galvanized steel sized according to NFPA 24, thoroughly coated with bituminous paint.

2.8 CONCRETE ENCASEMENT AND CRADLES

A. Concrete:

1. As specified in Section 03 30 00 - Cast-in-Place Concrete.

2. Type: air entrained.

3. Compressive Strength: 4,000 psi at 28 days.

4. Finish: Rough troweled.

2.9 MATERIALS

A. Bedding and Cover:

1. Bedding: Per trench detail(s) in plans.

2. Cover: Minimum cover per plans.

3. Soil Backfill from above Pipe to Finish Grade: Per trench detail(s) in plans.

2.10 ACCESSORIES

A. Manhole and Cover: As specified in Section 33 05 61 - Public Manholes and Structures.

B. Steel Rods, Bolt, Lugs, and Brackets:

1. Comply with ASTM A36 or ASTM A307.

2. Grade A carbon steel.

C. Protective Coating: Bituminous.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation examination.

B. Verify that existing utility water main size, location, and invert are as indicated on Drawings.

3.2 PREPARATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for installation preparation.

B. Preconstruction Site Videos:

1. Take digital video along centerline of proposed pipe trench.

2. Show mailboxes, curbing, lawns, driveways, signs, culverts, and other existing Site features.

3. Include Project description and date taken.

C. Pipe Cutting:

1. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, and remove burrs.

2. Use only equipment specifically designed for pipe cutting; use of chisels or hand saws is not permitted.

3. Grind edges smooth with beveled end for push-on connections.

D. Remove scale and dirt on inside and outside before assembly.

E. Prepare pipe connections to equipment with flanges or unions.

3.3 INSTALLATION

A. Bedding:

1. Excavation:

    a. Excavate pipe trench as specified in Section 31 23 17 - Trenching for Work of this Section.

    b. Hand trim excavation for accurate placement of pipe to elevations as indicated on Drawings.

2. Dewater excavations to maintain dry conditions and to preserve final grades at bottom of excavation.

3. Provide sheeting and shoring as specified in Section 31 23 17 - Trenching.

4. Bedding shall be Class I or Class II granular material. Class I material shall be shovel sliced or otherwise carefully placed and "walked" or hand tamped into place from 3 to 6 inches below the pipe barrel (depending on pipe diameter) to 1/6th the outside diameter of the pipe. Class II material shall be compacted to minimum 90 percent Standard Proctor Density, expect where the edge of the pipe trench is located within the pavement zone, Class I material with the pavement zone shall be compacted to minimum 95 percent Standard Proctor Density.

5. The pavement zone is defined as the areas under and within 5 feet of any pavement, curb, gutter, sidewalk, or similar structure.

B. Piping:

1. Install pipe according to AWWA C600 and AWWA C605.

2. Handle and assemble pipe according to manufacturer instructions and as indicated on Drawings.

3. Steel Rods, Bolt, Lugs, and Brackets: Coat buried steel with one coat of coal tar coating before backfilling.

4. Maintain 10 feet horizontal and 18 inch vertical separation of water main from sewer piping according to Indiana code.

5. Install ductile-iron piping and fittings according to AWWA C600.

6. Flanged Joints: Not to be used in underground installations except within structures.

7. Route pipe in straight line; re-lay pipe that is out of alignment or grade. Whenever pipe deflection is required for alignment or grade, the amount of deflection shall not exceed manufacturer maximum allowable deflection. Deflection in excess of the maximum allowable shall not be permitted and the Contractor shall install fittings at no additional cost to the Owner.

8. As each length of pipe is installed, joint the pipe to previously installed pipe. Bring the pipe to the correct line and grade and secure in place with bedding tamped under and around each side of the pipe. Backfill material shall be deposited and compacted uniformly and simultaneously on each side of pipe to prevent lateral displacement.

9. The cutting of pipe shall be done in a neat and workmanlike manner without damage to the cement lining of DI pipe. Use a cutting machine so as to leave a smooth end at right angles to the axis of the pipe. Flame cutting of pipe shall not be permitted. Bevel the edges of all pipe after cutting.

10. High Points:

    a. Install pipe with no high points.

    b. If unforeseen field conditions arise that necessitate high points, install air release valves as directed by Engineer.

11. Bearing:

    a. Install pipe to have bearing along entire length of pipe.

    b. Excavate bell holes to permit proper joint installation.

    c. Do not lay pipe in wet or frozen trench.

12. Prevent foreign material from entering pipe, fittings, hydrants, or valves during placement.

13. Install pipe to allow for expansion and contraction without stressing pipe or joints.

14. Close pipe openings with watertight plugs during Work stoppages.

15. Install access fittings to permit disinfection of water system performed under Section 33 13 00 - Disinfecting of Water Utility Distribution.

16. Cover:

    a. Establish elevations of buried piping with not less than minimum cover per plans.

    b. Measure depth of cover from final surface grade to top of pipe barrel.

17. Pipe Markers:

    a. Install trace wire continuous over top of pipe and plastic ribbon tape buried 18 inches above piping.

    b. Coordinate with trench Work as specified in Section 31 23 17 - Trenching.

18. Installation Standards: Install Work according to applicable local, state, and federal standards.

C. Tapping Sleeves and Valves:

1. As indicated on Shop Drawings, Drawings, and according to manufacturer instructions.

D. Meters:

1. Install meters as specified in Section 33 12 33 – Water Utility Metering.

E. Polyethylene Encasement:

1. Encase ductile iron piping in polyethylene to prevent contact with surrounding backfill material.

2. Comply with AWWA C105.

3. Terminate encasement 3 to 6 inches above ground where pipe is exposed.

F. Service Connections:

1. As specified in Section 33 12 13 - Water Service Connections.

G. Backfilling:

1. Backfill per trench detail(s) in plans.

2. Maintain optimum moisture content of bedding material to attain required compaction density.

H. Disinfection of Potable Water Piping System:

1. As specified in Section 33 13 00 - Disinfecting of Water Utility Distribution.

3.4 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Requirements for tolerances.

B. Install pipe to indicated elevation within tolerance of 5/8 inch.

3.5 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for inspecting and testing.

B. Pressure test system according to AWWA C600 and following:

1. Test Pressure: Not less than 150 psig or 50 psi in excess of maximum static pressure, whichever is greater.

2. Conduct hydrostatic test for at least two hours.

3. Slowly fill section to be tested with water; expel air from piping at high points. Install corporation cocks at high points. Close air vents and corporation cocks after air is expelled. Raise pressure to specified test pressure.

4. Observe joints, fittings, and valves under test. Remove and renew cracked pipes, joints, fittings, and valves showing visible leakage. Retest.

5. Correct visible deficiencies and continue testing at same test pressure for additional two hours to determine leakage rate. Maintain pressure within plus or minus 5 psi of test pressure. Leakage is defined as quantity of water supplied to piping necessary to maintain test pressure during period of test.

6. Compute maximum allowable leakage using following formula:

L = SD x sqrt(P)/C
L = testing allowance, gph
S = length of pipe tested, feet
D = nominal diameter of pipe, inches
P = average test pressure during hydrostatic test, psig
C = 148,000
When pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.

7. Allowable leakage for Mechanical Joint or Push-on Joint Pipe is provided in the following tables:

AVG. TEST PRESSURE PSI	PIPE SIZE - INCH										
	2	3	4	6	8	10	12	14	16	18	20
	*Allowable Leakage per 1,000 ft. of pipe (Gal./2 hours)										
250	0.43	0.64	0.85	1.28	1.71	2.14	2.56	2.99	3.42	3.85	4.27
225	0.41	0.61	0.81	1.22	1.62	2.03	2.43	2.84	3.24	3.65	4.05
200	0.38	0.57	0.76	1.15	1.53	1.91	2.29	2.68	3.06	3.44	3.82
175	0.36	0.54	0.72	1.07	1.43	1.79	2.15	2.50	2.86	3.22	3.58
150	0.33	0.50	0.66	0.99	1.32	1.66	1.99	2.32	2.65	2.98	3.31
140	0.32	0.48	0.64	0.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20
130	0.31	0.46	0.62	0.92	1.23	1.54	1.85	2.16	2.47	2.77	3.08
120	0.30	0.44	0.59	0.89	1.18	1.48	1.78	2.07	2.37	2.66	2.96
110	0.28	0.43	0.57	0.85	1.13	1.42	1.70	1.98	2.27	2.55	2.83
100	0.27	0.41	0.54	0.81	1.08	1.35	1.62	1.89	2.16	2.43	2.70
90	0.26	0.38	0.51	0.77	1.03	1.28	1.54	1.79	2.05	2.31	2.56
80	0.24	0.36	0.48	0.73	0.97	1.21	1.45	1.69	1.93	2.18	2.42
70	0.23	0.34	0.45	0.68	0.90	1.13	1.36	1.58	1.81	2.04	2.26
60	0.21	0.31	0.42	0.63	0.84	1.05	1.26	1.47	1.67	1.88	2.09
50	0.19	0.29	0.38	0.57	0.76	0.96	1.15	1.34	1.53	1.72	1.91
40	0.17	0.26	0.34	0.51	0.68	0.85	1.03	1.20	1.37	1.54	1.71

AVG. TEST PRESSURE PSI	PIPE SIZE - INCH				
	24	30	36	42	48
	* Allowable Leakage per 1,000 ft. of pipe (Gal./2 hours)				
250	5.13	6.41	7.69	8.97	10.26
225	4.86	6.08	7.30	8.51	9.73
200	4.59	5.73	6.88	8.03	9.17
175	4.29	5.36	6.44	7.51	8.58
150	3.97	4.97	5.96	6.95	7.94
140	3.84	4.80	5.76	6.72	7.67
130	3.70	4.62	5.55	6.47	7.40
120	3.55	4.44	5.33	6.22	7.11
110	3.40	4.25	5.10	5.95	6.80
100	3.24	4.05	4.86	5.68	6.49
90	3.08	3.85	4.62	5.38	6.15
80	2.90	3.63	4.35	5.08	5.80
70	2.71	3.39	4.07	4.75	5.43
60	2.51	3.14	3.77	4.40	5.02
50	2.29	2.87	3.44	4.01	4.59
40	2.05	2.56	3.08	3.59	4.10

* The allowable leakage for a pipeline to be calculated by multiplying the leakage per 2 hours per 1,000 ft. at the average test pressure and for the diameter of pipe tested as obtained from the above table and the total length of the line being tested divided by 1,000. If the line under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each pipe.

8. Leakage:

   a. If test of pipe indicates leakage greater than allowed, the Contractor, at his own expense, shall locate source of leakage, make corrections, and retest until leakage is within allowable limits. All material for this work shall be at the Contractor's expense.

   b. Correct visible leaks regardless of quantity of leakage.

C. If tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

END OF SECTION

SECTION 33 31 00

SANITARY SEWER SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sanitary sewage pipe.
   2. Underground pipe markers.

1.2 REFERENCES

A. ASTM International:
   1. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
   2. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   3. ASTM D3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   4. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

1.3 DEFINITIONS

A. Bedding: Fill placed under, beside and directly over pipe, prior to subsequent backfill operations.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data indicating pipe material used and pipe accessories.

C. Manufacturer's Installation Instructions: Indicate special procedures required to install Products specified.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution Requirements: Requirements for submittals.

B. Project Record Documents: Record location of pipe runs, connections, cleanouts, and invert elevations.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

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1.6 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

1.7 FIELD MEASUREMENTS

A. Verify field measurements and elevations are as indicated.

1.8 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Coordinate the Work with termination of sanitary sewer connection outside building, connection to municipal sewer utility service, and trenching.

PART 2 - PRODUCTS

2.1 SANITARY SEWAGE PIPE

A. Polyvinyl Chloride Pipe
   1. Sanitary sewer PVC pipe and fittings less than 18 inches in diameter shall be in accordance with the requirements of ASTM D3034, Type PSM, with a maximum SDR of 35 and elastomeric gasket joints.
   2. Elastomeric gasket joints shall be in accordance with the requirements of ASTM D3212.
   3. Elastomeric seals (gaskets) shall be in accordance with the requirements of ASTM F477.

2.2 UNDERGROUND PIPE MARKERS

A. Manufacturers:
   1. Seton Name Plate Corp.
   2. Allen Systems, Inc.
   3. Emed Co., Inc.
   4. Linetec, Inc.
   5. Substitutions: Section 01 60 00 - Product Requirements.

B. Underground-Type Plastic Line Markers: Manufacturer's standard permanent bright-colored, continuous-printed plastic tape with metallic lining, intended for direct burial service, not less than 6" wide x 4 mils thick. Provide green tape with black printing reading "Caution Sewer Line Buried Below".

2.3 EQUIPMENT

A. The Contractor shall furnish all equipment and personnel required to make all test including weirs, pipe stoppers, air compressor, air storage tank, pressure regulating valves, pressure gauges, stopwatch, etc., Contractor shall take precautions necessary, including blocking of stoppers or plugs, to protect the safety of property and personnel.

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B. Contractor shall provide groundwater gauges, wells or other means as required to measure the groundwater level. Such gauges, wells or other means shall be removed by Contractor after testing unless otherwise directed by the Owner.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.2 GENERAL CONSTRUCTION REQUIREMENTS

A. Before installing piping, the Contractor shall carefully verify location, depth, type of joint needed and size of pipe to which connection is proposed. He shall assure himself that the lines can be run as contemplated without interfering with footings, walls, other piping, fixtures, etc. Any necessary deviation shall be referred to the A/E in writing for final approval before lines are run.

B. All lengths of pipe shall be dimensioned accurately to measurements established at the site and shall be worked into place without springing or forcing. Cut sections of pipe shall be reamed to remove all burrs.

C. Utmost care shall be exercised in transporting and handling all pipe, fittings, valves, etc., in order to avoid shock and damage to pipe and coatings. Lifting's shall be hoist or skids when hand lifting is not feasible. Dropping will not be permitted. Pipe handled on skidways must not be skidded or rolled against pipe already on the ground. Damaged or defective pipe and appurtenances shall be replaced.

D. Pipe laying shall proceed upgrade with the spigot ends of bell and spigot pipe pointing in the direction of flow. Each pipe shall be laid accurately to the line and grade shown on the Drawings. Pipe shall be laid and centered so that the sewer has a uniform invert. As the work progresses, the interior of the sewer shall be cleared of all superfluous materials.

E. Before making pipe joints, all surfaces of the portions of the pipe to be joined shall be clean and dry. Lubricants, primers, and adhesives shall be used as recommended by the pipe manufacturer. The joints shall then be placed, fitted, joined, and adjusted so as to obtain the degree of water tightness required.

F. The Contractor shall cut all pipe and drill all holes that may be necessary.

G. All changes in direction shall be made with fittings. Bending pipe is prohibited. Any transition from one pipe size to another shall be made with a reducing fitting. Reducing bushings are prohibited except where specifically called for on the Drawings or unless approved by the A/E.

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3.3 INSTALLATION OF IDENTIFICATION

A. During backfilling of pipe lines, install continuous underground type plastic line marker, located directly over buried line at 6" to 8" below finished grade.

3.4 TEMPORARY PLUGS

A. Installed piping systems shall be temporarily plugged at the end of each day's work or other interruption to progress on a given line. Plugging shall be installed in a manner satisfactory to the Designer, and it shall be adequate to prevent entry of animals into the pipe or the entrance or insertion of deleterious materials.

B. Standard plugs shall be inserted into all dead-end pipes, tees, or crossings; spigot ends shall be capped; flanged ends shall have blind flanges of sheet metal or plywood.

C. Plugs installed for pressure testing shall be fully secured and blocked to withstand the test pressure.

D. Where plugging is required because of contract division or phasing for later connection, the ends of such lines shall be equipped with a permanent type plug or blind flange. Installation or removal of such plugging shall be considered incidental to the Work.

3.5 INSTALLATION

A. Polyvinyl chloride pipe shall be installed in accordance with ASTM D2321.

B. Push-On Joints: All foreign matter shall be wiped off the mating surfaces of the compression joint. The surfaces should then be coated with a lubricating material furnished by the pipe manufacturer to overcome the frictional resistance. Joint assembly shall then be completed by forcing the plain end of the entering pipe into the bell end of the preceding pipe section.

3.6 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Source and quality of water, test procedures, and disposal of water or other fluid shall be approved by the Owner.

C. All tests shall be made in the presence of the local utility. Preliminary tests made by the Contractor without being observed by the local utility will not be accepted. Notify the local utility at least 48 hours before any work is to be inspected or tested.

D. All defects in piping systems shall be repaired and/or replaced and retested until acceptable to the local utility. Repairs shall be made to the standard of quality specified for the entire system.

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E. Sections of the system may be tested separately, but any defect that may develop in a section previously tested and accepted shall be promptly corrected and retested.

F. All leaks discovered within one (1) year from the date of final acceptance of the work by the Owner shall be located, repaired and retested by the Contractor, regardless of the total line leakage rate, at no additional cost to the Owner.

G. Deflection testing shall be performed for all installed flexible sewer piping, except for house service piping. Flexible piping includes PVC piping.

3.7 GRAVITY SEWER LEAKAGE TESTING

A. Flush all lines with water prior to testing. The minimum flushing velocity shall be 2.5 fps.

B. Infiltration Test:
   1. When the groundwater level is two (2) feet or more above the crown of the entire pipe length, an infiltration test shall be made by sealing off a length of sewer and measuring the depth of flow over a measuring weir, or by pumping the infiltrated water into containers for measurement. Tests shall be conducted for a minimum of four (4) hours. Infiltration leakage shall not exceed 200 gallons per 24 hours, per inch diameter, per mile of sewer.

C. Exfiltration Test:
   1. When the grounds water level is less than two (2) feet above the crown of the entire pipe length, the sewer shall be tested for leakage by exfiltration. Exfiltration leakage test shall consist of isolating the particular section and filling it with water to a point at least two (2) feet above the crown of the pipe at the upper manhole or at least two (2) feet above the groundwater level at the upper manhole, whichever is higher, and allowing it to stand not less than four (4) hours. The section shall then be refilled with water up to the original point and after four (4) hours the drop in water surface shall be measured. The water level must not drop more than six (6) inches during the test. If the water level drops more than six (6) inches during the test, then a measured volume of water is to be added during the test to raise the water level to the starting elevation. The computed leakage shall not exceed 200 gallons per 24 hours, per inch diameter, per mile of sewer.

D. Air Test:
   1. Air tests are acceptable in lieu of infiltration/exfiltration testing. The sewer line to be tested shall be tested in increments between manholes. The line shall be sealed at each end. The seal at one end shall have an orifice through which to pass air into the pipe. An air supply shall be connected to the orifice at one end of the line. The air supply line shall contain an on-off gas valve and a pressure gauge having a range of from 0 to 10 PSI. The gauge shall have minimum division of 0.10 PSI and shall have an accuracy of $\pm$ 0.04 PSI.
   2. The pipeline under test shall be pressurized to 4 PSIG. The line shall be allowed to stabilize between 4 PSIG and 3.4 PSIG for a period of no less than 5 minutes. If necessary, air shall be added to the line to maintain the pressure above 3.5

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PSIG. After the stabilization period, the gas valve shall be closed. When the line pressure drops to 3.5 PSIG, commence timing with a stopwatch.

The stopwatch shall be allowed to run until such time as the line pressure drops to 2.5 PSIG. Then the watch shall be stopped and the time lapse compared with the allowable time lapse shown.

Nominal Pipe Size, In.	T(time) Min/100 ft.	Nominal Pipe Size, In.	T(time) Min/100 ft.
3	0.2	21	3.0
4	0.3	24	3.6
6	0.7	27	4.2
8	1.2	30	4.8
10	1.5	33	5.4
12	1.8	36	6.0
15	2.1	39	6.6
18	2.4	42	7.3

3. If the time lapse is greater than that specified, the section undergoing tests shall have passed. If the time is less than that specified, the line has not passed the test and the Subcontractor shall be required to make all repairs and retests. If the pipeline to be tested is beneath the groundwater level, the test pressure shall be increased 0.433 PSI for each foot the underground level is above the average crown elevation of the pipe.

E. Repair:
1. When leakage occurs in excess of the specified limits, defective pipe or joints shall be located and repaired. The Contractor, at his own expense, shall remove and reconstruct as much of the original work as necessary to obtain a sewer test within the allowable leakage limits.

3.8 DEFLECTION TESTING

A. A deflection test shall be performed on the entire length of installed flexible sewer piping upon the completion of all work, including the leakage test, backfill, and placement of any fill, grading, paving, concrete, or superimposed loads.

B. Deflection shall be determined by use of a deflection device or by use of a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft.

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C. The ball cylinder, or circular sections shall meet the following requirements:
   1. Have a diameter, or minor diameter as applicable, of 95 percent of the normal inside diameter of the pipe. A tolerance of plus 0.5 percent will be permitted.
   2. The ball, cylinder, or circular sections shall be of a homogeneous material throughout, shall have a density greater than 1.0 as related to water at 39.2EF, and shall have a surface brinell hardness of not less than 150.
   3. The ball, cylinder, or circular sections shall be center bored and through bolted with a 1/4-inch minimum diameter steel shaft having a yield strength of 70,000 psi or more, with eyes at each end for attaching pulling cables. The eyes (or loops) shall be suitably backed with flange or heavy washer such that a pull exerted on the opposite end of the shaft shall produce compression throughout the remote end of the ball, cylinder or circular sections.
   4. Circular sections shall be so spaced that the distance from the external faces of the front and back sections shall equal or exceed the diameter of the circular sections.

D. Failure of the ball, cylinder, or circular sections to pass freely through a pipe run, either by being pulled through or by being flushed through with water, shall be cause for rejection of that run.

E. When a deflection device is used for the test in lieu of the ball, cylinder, or circular sections, such device shall be approved by the Owner prior to use. The device shall be sensitive to 1.0 percent of the diameter of the pipe being measured and shall be accurate to 1.0 percent of the indicated dimension.

F. Installed pipe showing deflections of 5.0 percent of the normal diameter of the pipe or more shall be retested by a run from the opposite directions. If the retest indicates a deflection in excess of 5.0 percent, the suspect pipe shall be rejected.

G. Any pipe showing deflections in excess of 5 percent within one (1) year from the date of final acceptance of the work by the Owner shall be replaced by the Contractor at no cost to the Owner.

H. All rejected sewer pipe due to excessive deflection shall be replaced by the Contractor at no cost to the Owner.

3.9 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution Requirements: Requirements for protecting finished Work.

B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

END OF SECTION

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SECTION 33 32 00

MUFFIN MONSTER MANHOLE
SERIES 30005-0012 ELECTRIC GRINDER – FIBERGLASS MANHOLE - CONTROLLER
(2-Inch Hex Design)

PART 1 GENERAL

1.1 SUMMARY

A. This section of the specification describes the Muffin Monster Manhole. The equipment shall be installed as shown on the plans, as recommended by the supplier, and in compliance with all OSHA, local, state and federal codes and regulations.

B. The number of Muffin Monster Manholes shall be ___1___.

1.2 REFERENCES

A. The Muffin Monster Manhole shall, as applicable, meet the requirements of the following industry standards:

1. American Society for Testing and Materials (ASTM) D3753-81: Fiber-Reinforced Polyester Manholes.

B. The Muffin Monster Manhole Grinder(s) shall, as applicable, meet the requirements of the following industry standards:

1. American Society for Testing and Materials (ASTM) A36: Carbon Steel Plate
2. American Society for Testing and Materials (ASTM) A536-84: Ferritic Ductile Iron Castings
3. American Society for Testing and Materials (ASTM) A48-83: Grey Iron Casting
4. American National Standards Institute (ANSI) B16.42-1979, Class 150 Flanges
5. American Iron and Steel Institute (AISI) 303 Stainless Steel
6. American Iron and Steel Institute (AISI) 304 Stainless Steel
7. American Iron and Steel Institute (AISI) 316 Stainless Steel
8. American Iron and Steel Institute (AISI) 4130 Heat Treated Alloy Steel
9. American Iron and Steel Institute (AISI) 4140 Heat Treated Alloy Steel
10. American Iron and Steel Institute (AISI) 8620 Heat Treated Alloy Steel
11. American Iron and Steel Institute (AISI) 17-4 Stainless Steel

12. Society of Automotive Engineers (SAE) 660 Bearing Bronze

C. Controllers shall, as applicable, meet the requirements of the following Regulatory Agencies:

1. National Electrical Manufacturer's Association (NEMA) Standards

2. National Electric Code (NEC)

3. Underwriters Laboratory (UL and cUL)

4. International Electrotechnical Commission (IEC)

1.3 DOCUMENTS

A. Submittals

Supplier shall submit _4_ sets of submittals. Submittals shall include equipment descriptions, functional descriptions, dimensional and assembly drawings, catalog data, and job specific drawings.

B. Operation and Maintenance Manuals

The supplier shall provide _4_ Operation & Maintenance manuals. An electronic version shall be supplied to create additional copies. The manuals shall include equipment descriptions, operating instructions, drawings, troubleshooting techniques, a recommended schedule, and the recommended lubricants.

1.4 QUALITY ASSURANCE

A. Identification

1. Equipment shall be identified with a corrosion resistant nameplate affixed in a conspicuous location.

2. Nameplate information shall include manufacturer's name and address, equipment model number, and serial number.

B. Manufacturer

1. Supplier shall be ISO9001 certified and have a minimum 30 years experience as a manufacturer of municipal wastewater equipment and a minimum 5,000 prior installations of similar equipment.

2. Supplier shall provide a list of reference sites for similar equipment for verification by the Engineer or Owner's Representative.

3. Supplier shall conduct factory testing and verification of equipment prior to shipment.

4. Supplier shall have factory owned bi-coastal service centers.

C. Installation & Start-up

1. Supplier shall provide services of a factory trained representative to check installation and review start-up of equipment and controls.

2. Supplier Representative shall inspect and approve site installation and supervise a review of the operation of the equipment.

3. Supplier Representative shall provide training on operation and maintenance requirements of the equipment.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging

1. Containers or skids shall be constructed for normal shipping, handling, and storage.

2. Containers shall provide adequate protection for the equipment in a dry indoor environment between +40° F (+4.5° C) and +100° F (+37.8° C).

1.6 WARRANTY

Manufacturer's standard 12-month limited warranty shall be provided on equipment.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Muffin Monster Manhole shall be in accordance with these specifications and plans and shall be supplied by one of the following manufacturers:

1. JWC Environmental, 2850 Red Hill Avenue, Suite #125, Santa Ana, CA 92705
Tel: 800-331-2277
www.jwce.com

2. Approved equal.

B. Manufacturers requesting to be selected as an approved equal shall submit certified documentation including installation lists with phone numbers, equipment drawings, flow performance curves, electrical schematics and cut sheets, O&M draft showing compliance with these specifications a minimum of ten (10) days prior to bid opening. Selected equipment manufacturers shall be added to the list of approved manufacturers.

C. Selected approved equal manufacturers shall conduct an onsite test within ten (10) days of installation demonstrating compliance with all areas of this specification.

2.2 MUFFIN MONSTER MANHOLE

A. Summary

Grinder shall reduce or shred influent solids for protection of downstream equipment. Grinder shall be two shafted design consisting of individual cutters and spacers of equal diameter on both shafts. Grinder shall have high flow or slotted side rails. Grinder shall have an immersible motor and speed reducer for cutter drive.

Each manhole shall have a minimum ½-inch wall thickness, able to withstand a static load of 150 lb/ft per foot of depth with less than ¼-inch deflection. The manhole shall be fabricated with polyester resin, in one integral piece that is structurally strong, lightweight, watertight and corrosion resistant to salt water, ground water, corrosive soil conditions and many commonly encountered industrial chemicals.

The interior surface shall have a smooth white isophthalic gelcoat surface integral to the laminate and not applied as a spray on secondary process.

B Grinder Components

1. Cutters and Spacers

   a. Cutting stack shall be a nominal height of 12 inches (305 mm).

   b. Wipes Ready Cutters shall be an individual disk constructed of AISI alloy steel surface ground to thickness of .438-inches +.000/-.001 (11.1 mm +.000/-.003).

   c. Cutters shall be heat treated to produce a hardness of 45-53 Rockwell C.

   d. Wipes Ready Cutters shall have 17 cam shaped teeth with serrated leading edges. Tooth height shall not be greater than ½-inch (13 mm) above the root diameter of the cutter. OD shall be 4.73-inches (120.14 mm).

   e. Spacers shall be an individual disk constructed of 8620 steel surface ground to a thickness of .446-inches +.001/-.000 (11.3 mm +.003/-.000).

   f. Spacers shall have a hardness of 34-53 Rockwell C.

   g. Spacers shall have a knurled outside diameter with no tooth profiles.

2. Shafts

   a. Shafts shall be ASTM 4140 alloy steel with a minimum tensile strength of 149,000 PSI (1,027 kPA).

   b. Shafts shall be measured a nominal 2-inches (51 mm) across flats of hex.

   c. Shafts shall be hardened to 38-42 Rockwell C.

3. Seal Cartridges

a. Seal cartridges shall be rated to a maximum of 90 PSI (620 kPA).

b. Seal cartridges shall not require flushing.

c. Dynamic and rotating seal faces shall be tungsten carbide with 6% nickel binder.

d. O-rings shall be constructed of Buna-N (Nitrile).

e. Radial and axial loads shall be borne by sealed, oversized, deep-groove ball bearings.

4. Housings and Covers

a. Top cover and end housings shall be ASTM A536-84 ductile iron.

b. Bottom cover shall be ASTM A36 steel.

c. End housing shall have integral bushing deflectors to guide solids away from seal cartridges.

d. End housings shall have directional flow arrows cast into the external side walls.

5. Side Rails

a. Side rails shall be ASTM A536-84 ductile iron.

b. Side rails shall have evenly spaced horizontal slots to increase flow and decrease water head loss through the grinder. Slots shall only be located on the upstream or influent side of the rail and the effluent side of the rail shall be void of slots to allow for unobstructed flow.

c. Inside profile of the cutters shall be concave and follow the radial arc of the cutters.

d. Clearance between the outside diameter of cutters and concave arc of the side rail shall not exceed 5/16-inch (7.9 mm).

6. Speed Reducer

a. Reducer shall be manufactured by Sumitomo Machinery Corporation of America.

b. Reducer shall be internal planetary mechanism with trochoidal curved tooth profile.

c. Reducer shall be a vertically mounted with 29:1 single reduction.

d. Reducer shall be grease lubricated.

7. Motor

   a. Motor shall be manufactured by Baldor Electric Company.

   b. Motor shall be XPNV immersible – type, 5 hp (3.75 kW), 1770 rpm, 208-230/460 volt, 3 phase, 60 Hz. and shall have a 40’ power cable factory installed.

   c. Motor shall have a minimum service factor of 1.15, 91% minimum efficiency factor at full load, minimum 76% power factor at full load and rated at UL NEMA 6P (IP67+).

8. Grinder Performance

   a. The grinder will be capable of processing up to 620 GPM (39 L/S).

   b. Grinder shall provide peak shaft torque of 4,756 lb-in/hp (721 Nm/kW).

   c. Grinder shall provide peak force at cutter tip of 2,051 lb_f/hp (12,234 N/kW

C. Manhole Components

   a. Fiberglass barrel shall be 48 inches (121.92 cm) in diameter.

   b. Inlet and outlet pipe stubs, 6 inch (15.24 cm), 8 inch (20.32 cm), 10 inch (25.4 cm), or 12 inch (30.48 cm) with corresponding slip flange bolting connections for connection to incoming and outgoing pipes shall be supplied.

   c. Stainless steel (T-304) anchoring brackets (4) for anchoring manhole to concrete base shall be supplied.

   d. A ½ inch (1.27 cm) thick expanded polystyrene bead board for placement on concrete slab under manhole shall be supplied.

   e. Internally mounted fiberglass ladder with non-slip traction surface (meet or exceed OSHA General Industry Standards, Part 1910.27 for “Fixed Ladders” shall be supplied.

   f. Non-traffic areas above grade manhole shall have lockable fiberglass lid able to withstand 1000 lbs. (453.6 kg) topload.

   g. Traffic area manhole shall have concentric manway able to withstand 16,000 (7257.5 kg) vertical dynamic wheel load plus lateral forces with opening of 28 inches (71.12 cm) I.D. min. for use with cast-iron cover. To be supplied by other.

   h. Factory installed and tested internally mounted 306 SS (316 SS optional) guide rails for grinder installation and removal shall be supplied.

D. CONTROLLER

1. Controller shall provide control of the grinder and be designed to control one (1) 5 hp motor at 460 volts, 3 phase, 60 Hz. The controller shall have indicator lights, switches and other control devices.

   a. Enclosure shall be fiberglass reinforced polyester NEMA 4X .

   b. Enclosure shall house the control devices, motor starters, and PLC.

   c. Grinder ON-OFF/RESET-REMOTE three-position 22mm type, NEMA 4X selector switch

   d. In the OFF/RESET position, the grinder shall not run.

   e. In the ON position, the grinder shall run continuously.

   f. In the REMOTE position, the grinder shall start and stop as controlled by an external device.

   g. Selector switch shall be the only method for resetting the controller after a failure.

2. Pilot Lights

   a. Lights shall be LED type 22 mm, rated NEMA 4X.

   b. Lights shall indicate POWER ON, RUN, and FAIL.

3. Programmable Logic Controller (PLC)

   a. PLC shall be manufactured by Panasonic.

   b. PLC shall have a minimum of 16K of memory.

4. Motor Starter

   a. Starter shall be a full-voltage reversing type with 120 volt operating coils.

   b. Overload relays shall be adjustable and sized to full load amperes (FLA) of the motor.

5. Control Transformer

   a. Control transformer shall be minimum 130 VA.

   b. Control transformer primary and secondary shall be fused for over current protection.

6. Current Transducer

a. Current transducer shall be manufactured by Veris Industries.

b. Current transducer shall have adjustable set point from 1-135A with 200 ms or less response time.

7. Fail Conditions

a. When a grinder jam obstruction occurs, the controller shall stop the grinder and reverse the rotation to clear the obstruction. If the obstruction is cleared, the controller shall return the grinder to normal operation. If three (3) reverses occur within a 30 second interval, the controller shall stop the grinder motor in a jam condition and activate the grinder FAIL indicator and relay.

b. When a power failure occurs while the grinder is operating, the grinder will resume operation once power is restored.

c. When a power failure occurs while the grinder is in a fail condition, once power is restored the fail indicator shall reactivate and remain until reset.

d. Reset of the grinder shall be accomplished from the controller only.

PART 3 EXECUTION

3.1 INSTALLATION

Muffin Monster Manholes shall be installed in accordance with supplier's installation instructions, and in accordance with all OSHA, local, state, and federal codes and regulations.

3.2 TESTING

Test of grinder(s) shall demonstrate correct alignment, smooth operation. Test period shall demonstrate simulated jam condition for grinder.

3.3 TRAINING

A field training course shall be provided for operation and supervisory staff members. Field instruction shall cover items for successful operation contained in the operation & maintenance manuals.

END OF SECTION

SECTION 33 41 00

STORM DRAINAGE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Storm drainage piping.
2. Accessories.
3. Underground pipe markers.
4. Catch basins and plant area drains.
5. Cleanouts.
6. Bedding and cover materials.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:
1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
2. AASHTO M330 – Standard Specification for Polypropylene Pipe, 300- to 1500-mm (12- to 60-in) Diameter.

B. ASTM International:
1. ASTM C14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
2. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
3. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
4. ASTM C924 - Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method.
5. ASTM C969 - Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.
6. ASTM C1103 - Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.
7. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
8. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
9. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
10. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
11. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.

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12. ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
13. ASTM D2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
14. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
15. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
16. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
17. ASTM D3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
18. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

1.3 SUBMITTALS

A. None required.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with local utility and INDOT standards.

1.5 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.

B. Coordinate the Work with termination of storm sewer connection outside building, trenching, and connection to municipal sewer utility service.

PART 2 PRODUCTS

2.1 STORM DRAINAGE PIPING

A. Reinforced Concrete Pipe: ASTM C76, Class III nominal diameter as shown on the drawings.
   1. Fittings: Reinforced concrete.
   2. Joints: ASTM C443, rubber compression gasket.

B. Corrugated High Density Polyethylene (HDPE) Pipe: all corrugated high density polyethylene storm sewer pipe and fittings shall have a smooth interior. Diameters 12 inch to 36 inch shall conform to AASHTO M294 type S; 8 and 10 inch diameters shall meet the strength requirements of AASHTO M252 with the addition that the pipe have a smooth interior liner. Material shall conform to ASTM C3350.
   1. Installation shall be in accordance with the manufacturer’s published installation guide.

C. Plastic Pipe: ASTM D2751, SDR 35, Acrylonitrile-Butadiene-Styrene (ABS) material; inside nominal diameter of that shown on the drawings, bell and spigot style solvent sealed ends.

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1. Fittings: ABS.
2. Joints: ASTM D2235, solvent weld.

D. Polypropylene (PP) Pipe: AASHTO M330; All polypropylene storm sewer pipe shall have a smooth interior and annular exterior corrugations.
1. Fittings and Joints: ASTM F2881or AASHTO M330. Bell and Spigot.
2. Gaskets: ASTM F477; installed by pipe manufacturer.

2.2 UNDERGROUND PIPE MARKERS

A. Manufacturers:
1. Seton Name Plate Corp.
2. Allen Systems, Inc.
3. Emed Co., Inc.
4. Linetec, Inc.
5. Substitutions: Section 01 60 00 Product Requirements

B. Plastic Ribbon Tape: Bright colored, continuously printed, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

C. Trace Wire: Magnetic detectable conductor, brightly colored plastic covering, imprinted with "Storm Sewer Service" in large letters.

2.3 CATCH BASINS AND PLANT AREA DRAINS

A. Catch Basin Lid and Frame Manufacturers:
1. Neenah Foundry Co.
2. East Jordan Iron Works
3. Substitutions: Section 01 60 00 - Product Requirements

B. Catch Basin Lid and Frame:
1. As indicated on the drawings.

C. Shaft Construction and Eccentric Cone Top Section: Reinforced precast Concrete pipe sections, lipped male/female dry joints, nominal shaft diameter as shown on drawings.

D. Base Pad: Cast-in-place concrete of type specified in Section 01 30 00.

2.4 CLEANOUTS

A. Cleanout Lid and Frame Manufacturers:
1. As indicated on drawings.

2.5 BEDDING AND COVER MATERIALS

A. As shown in bedding details on drawings.

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PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify trench cut/excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.2 PREPARATION

A. Hand trim excavations to required elevations. Correct over excavation with coarse aggregate.

B. Remove large stones or other hard matter which could damage piping or impede consistent backfilling or compaction.

3.3 BEDDING

A. Excavate pipe trench in accordance with Section 31 23 17 for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.

B. Place bedding material at trench bottom, level materials in continuous layer not exceeding 6 inches compacted depth.

C. Maintain optimum moisture content of bedding material to attain required compaction density.

3.4 INSTALLATION - PIPE

A. Install pipe, fittings, and accessories in accordance with ASTM D2321. Seal joints watertight.

B. Lay pipe to slope gradients noted on drawings..

C. Install aggregate at sides and over top of pipe. Install top cover to minimum compacted thickness of 12 inches, compact to 95 percent.

D. Refer to Section 31 23 23 for backfilling and compacting requirements. Do not displace or damage pipe when compacting.

E. Refer to Section 33 05 13 for manhole requirements.

F. Install trace wire continuous over top of pipe buried 12 inches below finish grade, above pipe line; coordinate with Section 31 23 23, and 31 23 17.

G. Install Work in accordance with local utility and INDOT standards.

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3.5 INSTALLATION - CATCH BASINS AND CLEANOUTS

A. Form bottom of excavation clean and smooth to correct elevation.

B. Form and place Cast-In-Place Concrete base pad, with provision for storm sewer pipe end sections.

C. Level top surface of base pad; sleeve concrete shaft sections to receive storm sewer pipe sections.

D. Establish elevations and pipe inverts for inlets and outlets as indicated on Drawings.

E. Install Work in accordance with Municipality of Fishers and INDOT standards.

3.6 FIELD QUALITY CONTROL

A. Division 1 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Request inspection prior to and immediately after placing aggregate cover over pipe.

C. Compaction Testing: In accordance with ASTM D1557.

D. When tests indicate work does not meet specified requirements, remove work, replace and retest.

E. Infiltration Test: Test in accordance with ASTM 969.

F. Pressure Test: Test in accordance with ASTM C924 and ASTM C1103, depending on size of pipe.

3.7 PROTECTION OF FINISHED WORK

A. Division 1 - Execution Requirements: Protecting finished Work.

B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.
   1. Take care not to damage or displace installed pipe and joints during construction of pipe supports, backfilling, testing, and other operations.
   2. Repair or replace pipe that is damaged or displaced from construction operations.

END OF SECTION

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SECTION 33 46 00

SUBDRAINAGE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Building perimeter drainage system.
2. Retaining wall drainage system.
3. Slab-on-grade drainage system.
4. Filter aggregate and fabric.
5. Bedding.

1.2 REFERENCES

A. ASTM International:
1. ASTM C412 - Standard Specification for Concrete Drain Tile.
2. ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

1.3 SUBMITTALS

A. None required.

1.4 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution Requirements: Requirements for submittals.

B. Project Record Documents: Record location of pipe runs, connections, cleanouts and principal invert elevations.

C. Operation and Maintenance Data: Procedures for submittals.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with local standards.

PART 2 PRODUCTS

2.1 PIPE MATERIALS

A. Furnish materials in accordance with local standards.

B. Polyvinyl Chloride Pipe: ASTM D2729; plain end, 4 inch inside diameter; with required fittings.

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C. Use perforated pipe at subdrainage system; unperforated through sleeved walls.

2.2 AGGREGATE AND BEDDING

A. Filter Aggregate as shown on drawings

2.3 ACCESSORIES

A. Pipe Coupling: Solid plastic.

B. Filter Fabric: Water pervious type, black polyolefin or polyester manufactured by Akzo Nobel Geosynthetics Co.

C. Pipe Sleeve: Plastic type for foundation wall.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify excavated base is ready to receive work and excavations, dimensions, and elevations are as indicated on Drawings.

3.2 PREPARATION

A. Hand trim excavations to required elevations. Correct over excavation with Type A4 aggregate.

B. Remove large stones or other hard matter which could damage drainage piping or impede consistent backfilling or compaction.

3.3 INSTALLATION

A. Place drainage pipe on compacted impervious fill.

B. Lay pipe to slope gradients noted on Drawings; with maximum variation from indicated slope of 1/8 inch in 10 feet.

C. Place pipe with perforations facing down. Mechanically join pipe ends.

D. Install pipe couplings.

E. Install Type A1 A4 aggregate at sides, over joint and top of pipe. Install top cover compacted thickness of 12 inches.

F. Place filter fabric over leveled top surface of aggregate cover prior to subsequent backfilling operations.

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G. Place aggregate in maximum 6 inch lifts, consolidating each lift.

H. Refer to Section 31 23 23 for compaction requirements. Do not displace or damage pipe when compacting.

I. Place impervious fill over drainage pipe aggregate cover and compact.

J. Connect to storm sewer system with unperforated pipe.

3.4 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.

B. Request inspection prior to [and immediately after] placing aggregate cover over pipe.

3.5 PROTECTION OF INSTALLED CONSTRUCTION

A. Section 01 70 00 - Execution Requirements: Protecting installed construction.

B. Protect pipe and aggregate cover from damage or displacement until backfilling operation begins.

END OF SECTION

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